ASSESSING OPPORTUNITIES TO REDUCE THE ENVIRONMENTAL IMPACTS OF BREWERY WASTE IN ALBANIA

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Table of Contents

Table of Figures

1. Introduction

The 2017 United Nations World Water Development Report estimates that over 80% of wastewater produced worldwide is discharged into the environment without treatment. Lower middle-income countries only treat 28% of the wastewater they generate on average. This drops to 8% in low-income countries (UNESCO, 2017). Developing appropriate infrastructure to treat wastewater is difficult because there is little data regarding generation, treatment, and use of wastewater—only 55 out of 181 countries had full data sets in a recent analysis, but many were outdated (UNESCO, 2017). Target objective 6.3 of the UNESCO (United Nations Educational, Scientific and Cultural Organization) Sustainable Development Goals focuses on "reducing pollution and improving the disposal, management and treatment of wastewater and its impact on ambient water quality". Wastewater management is improved by reducing pollution at the generating source, removing contaminants from wastewater before it is discharged, and reusing water and useful byproducts.

Waste disposal infrastructure in Albania is still in the developmental stages. During the communist era in Albania, the Albanian socialist party developed wastewater disposal and water supply systems to match government directed population movements. The period between the fall of communism and the adoption of today's constitutional republic (1992-1998) was marked by social, political, and economic chaos. Large numbers of the population moved into Albania's major cities, but a fragile government and economy prevented infrastructure improvements from keeping pace with the redistribution of the population (Rohde et al., 2004). Today, there are eight urban wastewater treatment plants in Albania, but three of them are not in operation due to a lack of financial and technical support (United Nations Economic Commission for Europe, 2018). Together, these treatment plants have the capacity to treat approximately 25% of the country's wastewater. Poor wastewater treatment is accompanied by a lack of solid waste disposal infrastructure. Currently, only three sanitary landfills are in operation in Albania (United Nations Economic Commission for Europe, 2018).

Beer breweries are a large contributor to waste streams in Albania, but to what extent is unknown. Breweries consume huge quantities of water and produce large amounts of solid waste and wastewater. The average brewing process uses three to ten liters of water to produce one liter of beer (Werkneh et al., 2019). There are currently five large breweries and over eighty microbreweries in Albania (Mamillo, 2015). The Albanian brewing industry is growing, but how Albanian breweries are managing their waste is unclear. Our project sponsor, SHUKAlb (Water Supply and Sewerage Association of Albania) is interested in investigating current brewery practices and developing techniques to reduce the environmental impact of the solid waste and wastewater that Albanian breweries generate.

Breweries generate solid wastes in the form of spent grains, spent hops, trub, and yeast. Spent grains and yeast have a high protein content and can be used to supplement animal feeds (Farcas et al., 2017) (Brewers Association, 2016). Spent grains are also used in bakeries as a flour alternative and spent hops can be used as fertilizers and soil conditioners (Farcas et al., 2017). There are many options for reuse of the solid waste produced by breweries, but feasibility is dictated by cost and current infrastructure, which varies from brewery to brewery.

Wastewater is categorized by its physical and chemical contents. A combined brewery wastewater stream contains organic matter from the brewing process (spent grains, yeast, hops), cleaning chemicals and detergents, and waste from other points in the facility (Amenorfenyo et al., 2019). Brewery wastewater has a high organic load that is not suitable for direct discharge into the environment because it negatively impacts aquatic ecosystems. The Albanian government developed several sets of regulations regarding waste disposal (United Nations Economic Commission for Europe, 2018). While these laws have been in place for a number of years, compliance remains low due to lack of enforcement and resistance to change (United Nations Economic Commission for Europe, 2018). It is the goal of regulatory agencies within Albania to obtain full compliance from all industries.

Government regulations on waste management in countries like the United States mandate that breweries meet certain disposal standards. In the United States, brewery wastewater is discharged directly into the municipal water treatment system, partially treated before discharge into the sewer system, or fully treated on site and discharged into the environment. The design of a system depends on the properties, volume, and final destination of the wastewater—every system is unique (Brewers Association, 2016). Several published treatment methods effectively reduce the organic load of brewery wastewater and produce electricity, biogas, or biomass that serves as fertilizer or animal feed (Simate et. al., 2011). Wastewater reuse and reduction methods are also effective strategies for minimizing the environmental impact of breweries. Installing more efficient equipment or changing how the system runs can potentially reduce brewery wastewater volume (Brewers Association, 2016). Breweries can also reuse some wastewater streams, as not all components of the brewing processes require high quality water.

The goal of this project is to work alongside Albanian breweries, regulatory agencies, and members of the public to compile research on current practices and develop incentives and recommendations for improvements in brewery waste management. The team plans to travel to various breweries across Albania to conduct interviews and tours to assess how each brewery manages their waste. This will be coupled with research on current Albanian regulations and the team will interview members of the wastewater treatment industry to get a full picture of the impacts of brewery waste on the environment. We will also identify incentives for breweries to improve their practices by conducting a cost benefit analysis and surveying Albanian beer consumers. The research found throughout the duration of the project will lay a foundation to inform brewers on how they can make their processes more environmentally sustainable, as well as provide SHUKAlb with valuable information on industry practices not previously researched in Albania.

2. Background

Beer production in Albania began towards the end of the Ottoman Empire in the 1800s. Today, there are five large breweries and over eighty microbreweries in Albania. Beer is the third most consumed alcoholic beverage in Albania behind wine and raki, in terms of liters consumed. Brewing beer consumes large amounts of water and produces waste streams that significantly harm the environment when left untreated. The Water Supply and Sewerage Association of Albania (SHUKAlb) has developed initiatives to assess the environmental impact of Albania's current wastewater management practices. This project on assessing the impacts of brewing beer is a part of these initiatives.

Section 1 of this chapter provides an overview of the history, economic impacts, cultural importance, and consumption patterns of beer in Albania. Section 2 details the beer brewing process and the environmental impacts of brewery waste. Section 3 discusses water treatment and brewery waste management infrastructure in Albania. Section 4 describes wastewater treatment, reuse, and reduction methods in breweries, as well as reuse options for solid waste, such as spent grains and yeast. Section 5 provides an overview of possible incentives for breweries to implement sustainability initiatives. Section 6 discusses project stakeholders.

2.1 Growth of Beer Production in Albania

History of Beer in Albania

It is unclear when beer production first began in the Albanian region. Prior to the establishment of the Ottoman Empire in the 1400s, wine was widely produced and consumed in the Balkan region. During the Tanzimat period of social and political reform in the Ottoman Empire (1839-1876), Muslim attendance at meyhanes (traditional restaurants) rose. Muslims were typically barred from consuming alcohol, but during this period of reform their consumption of alcohol increased. Raki, a fruit brandy, became more popular in meyhanes and beer made its first appearances in the region during this time (Zat, 2012). Towards the end of the Ottoman Empire in 1896, changes to the tax laws made it more economical to produce beer than raki or wine. This stimulated the production of beer for the first time in the Albanian region (Shaw, 1975). In 1912 the Ottoman Empire fell, and Albania declared its independence.

Commercialized beer production in the country is relatively new. An Italian investor from Venice, Umberto Umberti, and native investor from Korça, Selim Mborja, founded the first Albanian brewery in 1929 with the approval of King Zog I and the Albanian parliament. The brewery was located in Korça and came to be known as Birra Korça. The Korça brewery produced blonde ale, schwarzbier (black beer), pale ale, and malt. Following WWII, communism rose to power and the Albanian state nationalized Birra Korça (Birra Korça 2017).

Beer production in the Birra Korça brewery varied during the communist era. Production declined from 10,000 hectoliters (1 hL=100 L) of beer per year to 600 hectoliters of beer per year between 1939 and 1943. In 1957, Birra Korça made several renovations, and the brewery began to produce up to 46,300 hectoliters of beer. In 1960, Birra Korça produced 52,000 hectoliters per year, a record high. In that same year, Birra Tirana became the second major brewery in Albania. Ali Kelmendi Food Combine, an ex-grocery store company, founded Birra Tirana (Birra Korça 2017).

The original technology in the Birra Tirana brewery was Russian and Czech based, with an initial production capacity of 75,000 hectoliters per year. The brewery began by producing blonde and brass pilsner beer. Originally, beer was sold in 0.5-liter glass bottles as well as in 50-liter barrels. In 1983, Birra Tirana had a renovation to its factory, increasing the production to 150,000 hectoliters per year. They replaced a majority of their production machinery with German and Swedish machinery (Birra Tirana 2019).

In the 1990's, the beer brewing industry in Albania began to expand as the economic structure transitioned from socialism to capitalism. Capitalism brought a relaxation of taxes, allowing for more economic freedom. This new government structure created opportunities to open new companies, and soon other beer producers including Birra Stelga, Birra Norga, and Birra Kaon entered the market, along with 80+ microbreweries spread across Albania (Mamillo, 2015).

Today's Albanian Breweries

Currently, there are five main breweries that dominate the domestic beer market in Albania, shown in Figure 1 (Mamillo 2015). These breweries include those founded throughout the Communist era as well as those that emerged after the regime's fall. In addition to the larger commercialized breweries, a variety of microbreweries which are limited-production breweries, are scattered throughout the region.

1. Birra Korça
2. Birra Tirana
3. Birra Norga
4. Birra Stela
5. Birra Kaon

Figure 1: Map of the 5 main breweries in Albania.

Since it was the first brewery established in Albania, Birra Korça has a rich history that spans different owners and renovations. The projected production of the brewery was originally 20,000 hectoliters per year (Birra Korça 2017). In 2004, the Hysenbelliu Group bought the Birra Korça brewery and completely revamped the factory, including new technological and construction upgrades. The new factory can now brew 120,000 hectoliters of beer annually (Birra Korça 2017).

While Birra Korça has a long-standing history within the country, Birra Tirana has been Albania’s largest beer production and marketing company since it was founded in 1960. In 2001, the government privatized Birra Tirana and a group of 10 prominent Albanian companies purchased 98% of it. The employees purchased the remaining 2%. After 2002, Birra Tirana began exporting to various countries including the United States, England, Greece, Switzerland, and more (Birra Tirana 2019).

The two oldest breweries are rivaled by three newer, larger, commercial breweries. After the turn to capitalism in 1991, Stefani and Company, a shareholding organization, founded Birra Stela.

Birra Stela's initial production capacity was 180,000 hectoliters of beer annually. Today, the company employs more than 130 people and produces more than 250,000 hectoliters of beer per year. Birra Stela is the second most popular beer in Albania, accounting for 15-18% of the beer consumption in the Albanian market (Stefani & Co., 2017).

TEA Company founded Birra Kaon in 1995. The company started out as a small-time brewery which eventually grew into one of the leading breweries in Albania. The brand was named Birra Kaon after Kaon, the Illyrian tribune from the first millennium BC which was "...known among other things for its ability to produce beer and have it taste good" (Birra Kaon 2017). While comparatively new, this brewery strives to reach the local culture of the founders' family and Albania.

The fifth main brewery in Albania is Birra Norga. There is limited information on Birra Norga. Dr. Mamillo of the University of Tirana stated that "Birra Norga is a new brand that entered the market in the 1990's, around the same time Birra Kaon joined the market. They were able to capture part of the beer market" (Mamillo, 2015).

Economic Impacts

While the average salary in Albania is about 444,000 Lek (4,020 USD) per year, the distribution of expenses is still around 12.8% to restaurants (Numbeo 2019). In America, the average household income is 78,635 USD (about 8.80 million Lek). Though the disparity is large between these cultures, Americans only spend 6.7% of their money to restaurants (U.S. Bureau). This suggests that the citizens of Albania still go out and spend money on food, drinks, alcohol, etc. despite a weak economy.

At a restaurant, domestic beer costs around 150 Lek, while imported beer costs around 187 Lek (100 Lek = 0.90 USD). Comparatively at a supermarket, domestic beer costs 90 Lek while imported beer costs 127 Lek on average (Numbeo 2019). It is evident that domestic beer produced in Albania costs less than imported beers.

2.2 Environmental Impacts of Brewery Waste

The beer brewing process produces both solid and liquid waste. Spent grain, spent hops, trub, and spent yeast are all forms of solid waste, while wastewater is produced all throughout the brewing process. Each of these wastes pose a different threat to the environment, which will be explained in detail throughout this section.

The Brewing Process

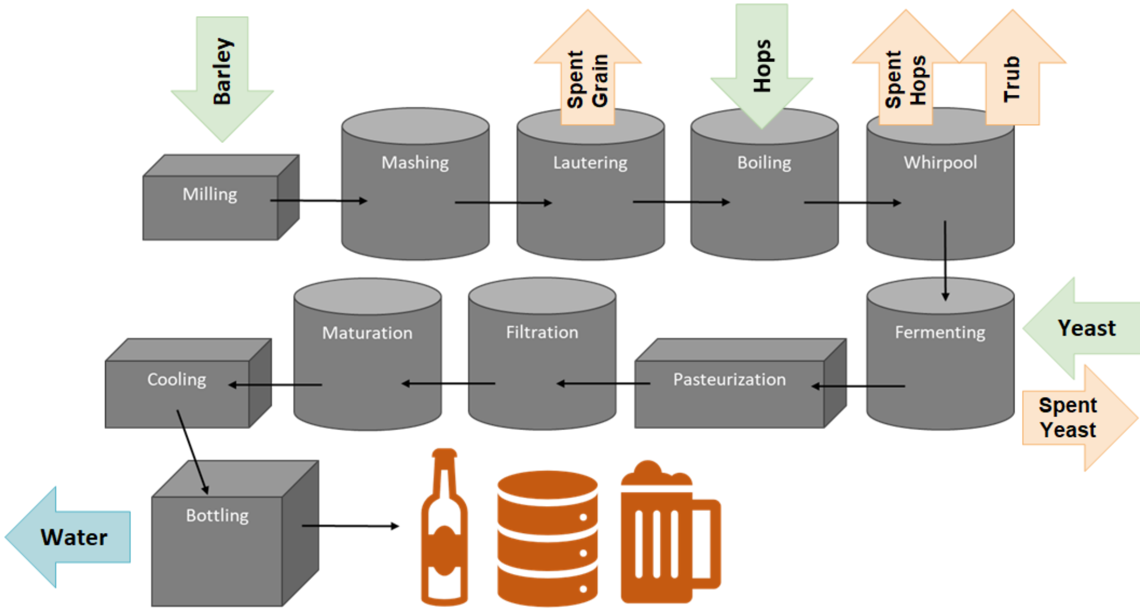

Figure 2: Beer brewing process flow diagram.

The brewing process begins with barley, a major cereal grain that is produced worldwide. When the grain is first obtained, it isn't particularly useful to the brewing process. Willaert (2007) notes that "Barley is able to produce all the enzymes that are needed to degrade starch, β-glucan, pentosans, lipids, and proteins, which are the major compounds of interest to the brewer." To prepare barley for brewing, a process called malting steeping occurs, where the grains are moistened and aerated to initiate germination (Mussatto et al., 2006). The wet grain mixture, now called malt, is kept at about 22 °C for three to five days, where the grains sprout and produce the enzymes of interest. It is then kilned or heated to temperatures of up to 110 °C, to stop the germination process, as well as to develop flavoring and coloring substances for the beer (Willaert, 2007).

Once the malt is fully dry, it moves onto a step called milling, where the grain is crushed but the husks are left intact. This releases the enzymes developed in the last step and increases the surface area of the grain. Next, the milled malt is mashed and lautered, which is the wort separation process. Wort is a sugar solution that comes from the boiling of the malt (S. Kmiotek, personal communication, September 05, 2019). Warm water is added to the milled malt and mixed to activate enzymes and break down compounds within the mixture. Spent grains are then removed from the mixture as waste, and ingredients such as hops, hops products and syrups are added for flavor and aroma.

The next step is to boil the wort to further develop the flavor, and to develop the hot break. The hot break coagulates proteins in the mixture so they can fall out of solution as trub. After this the wort is sent to a whirlpool system, where the spent hops and trub are removed as waste, and the mixture is rapidly cooled to prevent the formation of any bacteria. Yeast is then added to the wort, where it ferments anywhere from 2-15 days before the first amount of yeast is removed. Next, the beer is set to mature and condition, where features such as taste and CO_2 levels are adjusted to the brewer's liking. In the final steps, the beer is centrifuged and pasteurized to remove any remaining yeast and trub. Finally, it is filtered to remove any microorganisms before being packaged for consumption and sale (Willaert, 2007) (S. Kmiotek, personal communication, September 05, 2019).

Wastewater

Water is used throughout the brewing process in stages such as mashing, boiling, and packing, all of which generate wastewater. Wastewater contains cleaning detergents, chemicals, human excreta, yeast, and organic matter (Amenorfenyo et al., 2019). The majority of wastewater is produced during the cleaning process. Each tank involved in the brewing process, keg, and bottle need to be cleansed and rinsed after each batch and before the packaging process. The brewing process produces 3-10 liters of wastewater per every liter of beer produced (Werkneh et al., 2019). The amount of water used depends on the efficiency of the process and the type of beer produced but is between 5-6 liters of wastewater per liter of beer in an average process (Fillaudeau et al., 2006). While there are laws in place to regulate the disposal of wastewater from beer breweries, they are not strictly enforced by the Albanian government or any other organization. As a result, Albanian breweries dump almost all of their wastewater into local sewers or surrounding bodies of water, such as lakes, rivers, or streams.

Brewery wastewater has a high organic load, meaning that it has high levels of biological oxygen demand (BOD), chemical oxygen demand (COD), nitrogen, and phosphorous. High levels of BOD or COD cause dissolved oxygen levels in the receiving water body to decrease rapidly, resulting in conditions that are not suitable for aquatic species. Phosphorus and nitrogen are limiting nutrients in aquatic ecosystems; an increase in either can lead to algae blooms. This negatively impacts biodiversity and water quality (Brewers Association, 2016) (Simate et al., 2011).

This organic load also has a negative impact on the natural bacteria population surviving in these ecosystems. Majority of these bacteria are responsible for the biodegradation of harmful aromatic hydrocarbons. The increase of these hydrocarbons causes the water body to emit an awful smell (Iheukumere et. al. 2014). Another study, conducted by Devolli (2018), tested Albanian wastewater and found increased acidity levels and high overall temperature of the affected ecosystems. Allowing this untreated wastewater to be dumped into the sewer system, however, is also not a viable solution. The mixture of beer brewery effluent and sewer water creates an accelerated corrosion rate and produces methane gas (CH_4) and hydrogen sulfide (H_2S). Methane gas is a type of greenhouse gas which contributes to climate change when emitted to the atmosphere from these sewer systems.

Solid Waste

Solid waste is also generated throughout the brewing process, containing spent grain, yeast, and then spent hops and trub. Grain filtered from the wort is considered spent and is no longer of use to brewers. On average, 20 kg of spent grain is generated for every 100 liters of beer produced (Lynch et al., 2016). Spent grain can be rapidly colonized with bacteria and fungi, which also grow considerably well in beer. This presents a risk to the environment if large quantities of bacteria are dumped into the environment and left to grow in the waste. A method to reduce the risk of microorganism growth is the drying of the spent grain to inhibit extensive growth (Farcas et al., 2017).

High contents of nucleic acids are one of the main drawbacks of yeast waste. For monogastric animals, nucleic acids contribute to a decrease in digestibility, which causes a decrease in nutrition absorption and utilization. These acids are all potentially harmful to the environment if they're not properly disposed of or recycled in any way (Caballero-Córdoba, 2011). Hops and trub pose a threat to the environment as well, because the hops and trub waste contains 2-methyl-3-buten-2-ol, which is the product of the degradation of acids in the waste. This can cause hypnotic and sedative qualities if consumed in large concentrations, so any downstream consumption of the waste exposes this risk (Farcas et al., 2017).

2.3 Albanian Infrastructure to Dispose of Brewery Waste

There is limited data available for current waste treatment and disposal infrastructure in Albania. From 1941 to 1990, Albania was under communist rule, which greatly influenced infrastructure development. Socialist initiatives during this time resulted in rapid industrialization, a lack of environmental sensitivity, and strong urbanization (The World Bank, 2015). Water treatment and supply systems were developed to match the government directed population movements. After the fall of communism in 1990, population movement restrictions were eliminated, resulting "in an accelerated increase in rural to urban migration," (Rohde et al., 2004). Due to unstable political conditions in the years immediately after the fall of communism, Albanian water infrastructure did not keep up with changes in population, and any changes made were not regulated. With the growth of the population and economy in subsequent years and lack of infrastructure maintenance, many systems that were in operation during the communist period have now reached the end of their lifespan and cannot accommodate the volumes of wastewater produced (Rohde et al., 2004).

As of 2016, eight urban wastewater treatment plants have been constructed in Albania with donor support. These plants have the capability of treating approximately 25% of the country's urban wastewater with no mention of industrial wastewater capacity. Three of them were rendered idle because of lack of financial and technical support (United Nations Economic Commission for Europe, 2018).

Water treatment and distribution is not supported financially. On average, 67% of drinking water in Albania is non-revenue. Current tariffs do not cover costs incurred for water treatment, leaving water treatment and supply companies without sufficient financial capital to sustain and maintain their operations (United Nations Economic Commission for Europe, 2018). Approximately 30% of water production is billed to consumers, and only 62% of those bills are paid (Rohde et al., 2004). The majority of Albania relies on groundwater sources to supply water which typically requires little to no treatment. Areas with appropriate water treatment infrastructure, such as Tirana, may be supplied with treated surface water. Wastewater is largely discharged directly into the environment, polluting surface water bodies. Additionally, there is little infrastructure for solid waste disposal, as there are only three sanitary landfills in operation (United Nations Economic Commission for Europe, 2018). Without sufficient access to landfills, breweries may be limited to dumping their solid wastes at unregulated sites. Waste management regulations set by the Albanian government are difficult to enforce because there is not adequate water treatment and distribution and solid waste disposal infrastructure.

Researchers from the Agricultural University of Albania and the University of Tirana conducted a study on a brewery in Tirana. They noted that there was some treatment infrastructure in place in the brewery, including water reducing cleaning systems, separation processes for yeast and spent grain, and a "mixing and balancing tank" for wastewater before it was discharged to the municipal sewer system (Devolli et al., 2018). Yeast and spent grain were used for livestock feed. The study showed that the treatment methods only achieved a 40% reduction in organic load, and the effluent BOD_5 was 15.8 times above the allowable limit of 50 mg/L set by Albanian authorities. The effluent COD was 4.5 times more than the 250 mg/L limit. The researchers noted that "...strict legislation favors a reduction of water consumption and wastewater production in order to reduce the volume to treat" (Devolli et al., 2018).

2.4 Reuse, Treatment, and Reduction of Brewery Waste

Wastewater Treatment

Treating brewery wastewater before discharge into the environment is a strategy for reducing the environmental impact of brewing beer. There are many techniques for lowering the chemical and organic content of brewery wastewater before discharge. Treatment processes typically include physical, chemical, and biological treatment steps. The treatment process used in a specific brewery is dependent on the properties of the wastewater, its point of end use or discharge, and the size and location of the brewery (Brewers Association, 2016). Thus, there is not a one size fits all option—breweries must make treatment decisions based on their individual needs.

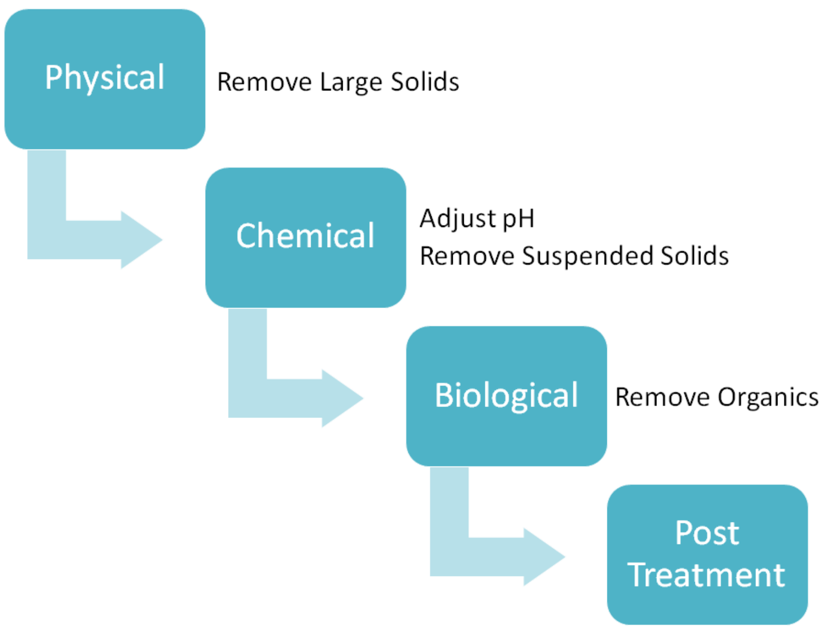

Figure 3: General wastewater treatment steps.

Most treatment processes involve an initial physical treatment method. Physical treatment methods remove solid matter, such as spent grain, but not dissolved pollutants like excess sugars or yeast. Physical treatment methods include passing the effluent stream through a filter or allowing solids to settle out of the effluent stream, also known as sedimentation (Simate et. al., 2011). Physical methods are generally a first step but do not provide complete treatment because they do not reduce the organic or chemical load of the waste stream.

Chemical treatments involve altering the water chemistry, so it is suitable for its final endpoint. The pH of the water impacts the effectiveness of chemical and biological treatment methods and the environment if it is discharged into a surface water source. Simate et. al. (2011) cite that waste CO_2 from the brewing process can be used to lower the pH of alkaline wastewater instead of using sulfuric or hydrochloric acids, which are both corrosive and costly. This reuses CO2 that would otherwise be released to the atmosphere and reduces the amount of hazardous chemicals used. Wastewater color can be treated through coagulation and flocculation. Coagulants are chemicals added to neutralize negative charges on dissolved particles. A flocculant is then added to gather the particles and precipitate them out of solution, removing turbidity and color from water (Fosso-Kankeu et. al., 2018).

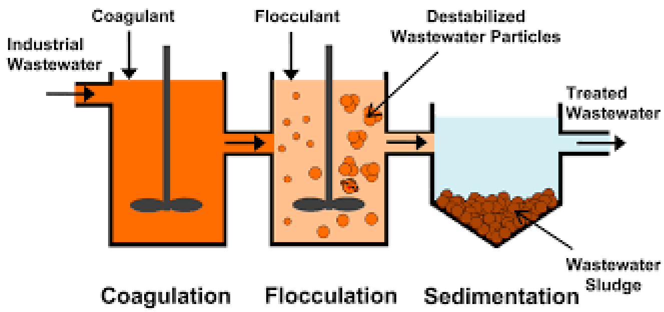

Figure 4: Flow diagram for a coagulation and flocculation process (Teh et al., 2016).

Following physical and chemical treatment, biological treatments are used. Biological treatments are widely employed in wastewater treatment plants, so this technology is well studied and proven to remove BOD (biological oxygen demand) and COD (chemical oxygen demand) in wastewater. Breweries around the world utilize biological processes to treat their wastewater prior to discharge. Biological methods typically have a low initial cost but require a large energy input (Simate et. al., 2011). Aerobic treatments use microorganisms in the presence of oxygen to metabolize organic matter. The byproducts are more microorganisms, CO_2, H_2O and NH_3. Activated sludge treatments are an example of aerobic treatment; wastewater and the active microorganisms are aerated in a tank to provide oxygen for the metabolization of the organic matter. Sierra Nevada Brewery in Chico, California uses a two-step aerobic an anaerobic treatment process (Brewers Association, 2016).

Figure 5: Bluetongue Brewery's aerobic membrane bioreactor post-treatment stage. Water in this stage is aerated in a mixing tank to supply oxygen to the microorganisms (CST Wastewater Solutions, n.d.).

Anaerobic treatments do not require oxygen. Microorganisms convert the organic matter in wastewater sludge into biogas (methane and carbon dioxide). Sludge is the solid organic matter that is precipitated out of the wastewater stream. Simate et. al. (2011) suggest that breweries can collect the biogas produced and use it to fuel boilers in the brewing process. This lowers energy costs and makes the brewing process more sustainable. Common anaerobic treatment methods are up flow anaerobic sludge blankets (UASB) and fluidized bed reactors (FBR) (Simate et. al., 2011). Anaerobic treatment is frequently followed by aerobic treatment to further reduce the COD of the wastewater. Bluetongue Brewery in Warnervale, Australia is an example of a brewery that is producing biogas from its wastewater. The brewery uses an anaerobic reactor to produce methane for subsequent boiler use. The effluent water is then treated by membrane bioreactor, a type of aerobic treatment, and a reverse osmosis installation before it is recycled back into the brewery (Brewers Association, 2016).

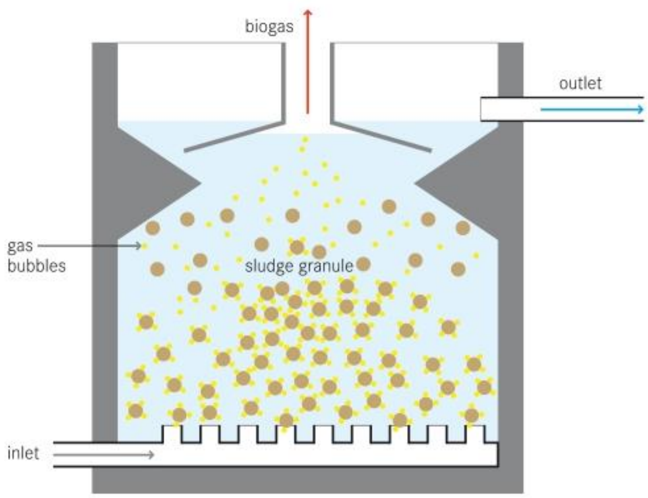

Figure 6: Schematic of a UASB reactor (Tilley et al., 2014).

Membrane filtration includes four subcategories based on the pore size of the membrane: microfiltration, ultrafiltration, nanofiltration, and hyperfiltration. Membranes are classified by their pore size and the material they are made of, ranging from ceramics to polymers (Simate et. al., 2011). Nanofiltration removed 100% of COD in biologically treated wastewater and ~90% of COD in water used for rinsing in the brewing process in a 2004 study published by researchers at the chemical engineering department of the University of Leuwen, Belgium (Braeken et al., 2004). Membrane filtration equipment is subject to fouling, so it works best with minimal turbidity and must be cleaned often (Simate et al., 2011). Membrane bioreactors (MBRs) are a combination of activated sludge and membrane treatments. There are two reactor configurations— the membrane media can be placed inside (submerged MBRs) or outside of the reactor (side stream MBR). These types of reactors are applied in drinking water and wastewater treatment, making them appropriate for the reuse of brewery wastewater (Simate et al., 2011).

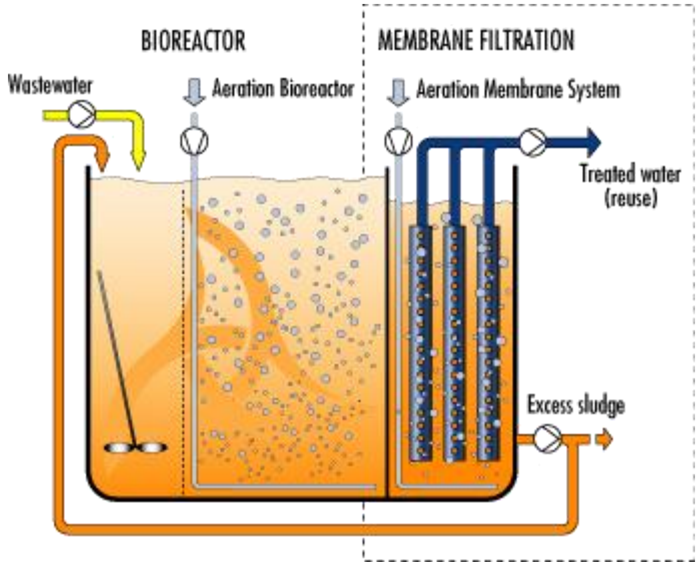

Figure 7: Diagram of a submerged MBR treatment system (Lenntech, n.d.).

Another method studied by a research group in the inorganic chemistry laboratory at the University of Yaounde, Cameroon is the use of non-thermal quenched plasma. Plasma is a state of matter where electrons have been removed from an atom and are free to react. Electrons in non-thermal quenched plasma have a much higher temperature than the surrounding atoms. When an electric gliding arc discharge is applied to humid air it produces -NO and -OH radicals, which are strong oxidants that can eliminate organic pollutants (Doubla et al., 2007). The study found that this technique reduces the BOD of brewery wastewater and simultaneously lowers the pH of alkaline wastewaters.

Electrochemical methods work with varying wastewater strength. In a study published in 2006, researchers from the University of Putra Malaysia used hypochlorous acid (HOCl) generated from NaCl in an electrolytic reactor to treat brewery wastewater (Vijayaraghavan et al., 2006). COD levels in the brewery wastewater fell by 97% when an NaCl concentration of 3% was used in the reactor. Bisulfite was added to remove residual chlorine and the water was passed through an activated carbon filter to produce wastewater suitable for discharge. In addition, the study noted that the effluent stream could be treated with reverse osmosis to meet reuse standards within the brewery.

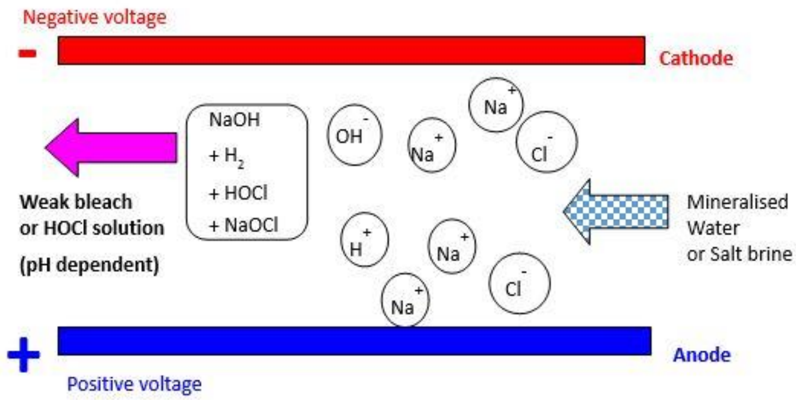

Figure 8: Production of HOCl from NaCl in an electrolytic reactor (ECA Consortium, 2017).

Microbial fuel cells (MFCs) produce energy by treating brewery wastewater. MFCs convert chemical energy from organic matter into electrical energy. An anode is exposed to the wastewater, and a cathode is exposed to a chemical electron acceptor like oxygen. As bacteria oxidize organic matter, electrons are captured by the anode and transferred through a circuit to the cathode where they combine with oxygen and form water (Simate et al., 2011). COD removal was more efficient, between 85% and 87%, in full strength wastewater in a study conducted at the Harbin Institute of Technology in China. Power outputs between 11-12 W/m3 were obtained (Wang et. al., 2008).

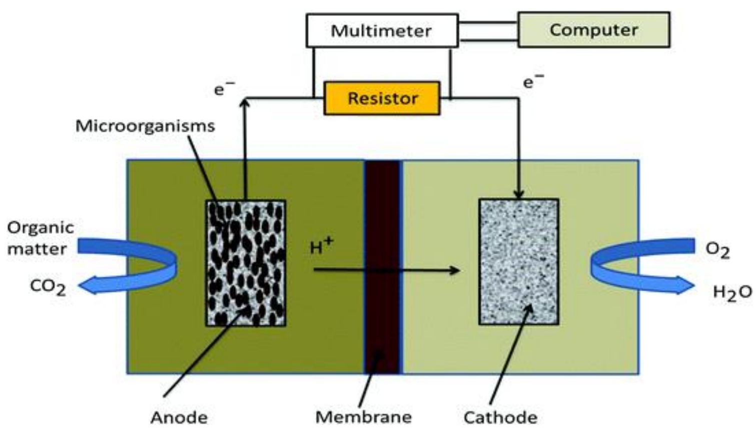

Figure 9: Microbial fuel cell diagram (Surajbhan et al., 2017).

Constructed wetlands (CWs) are widely used to treat winery wastewater, which has similar characteristics to brewery wastewater. In recent years, an increasing number of breweries have implemented CWs in their wastewater treatment schemes. CWs are engineered systems that use the natural functions of vegetation, soil, and organisms in conjunction with other pre- or post-treatments to reduce the organic load of wastewater before it is discharged into the environment. The complexity and size of a CW is dependent on the volume of water treated and what it contains (Masi & Bresciani, 2018). CWs are able to treat varying flow rates and effluent concentrations. Masi and Bresciani speculate that CWs have not been more widely adopted by breweries because of the location of their facilities and the availability of land. In Tirana, Albania a CW was put in place at the Bregu Lumit in the north eastern area of the city to reduce nutrient inputs into the Tirana River from an urban area (Miho et al., 2010). This CW was not a sufficient method for reducing pollution in the Tirana River because of the population density, but may have been suitable in decentralized water treatment, in isolated settlements or other activities (Miho et al., 2010).

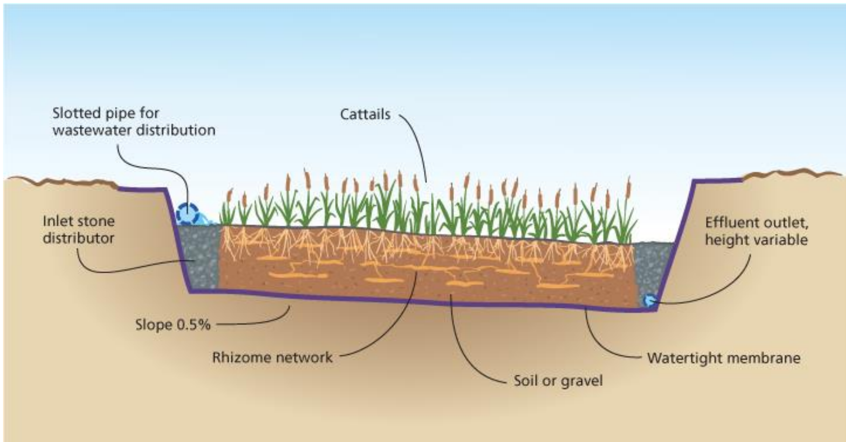

Figure 10: Constructed wetland diagram (Grismer, 2011).

Activated carbon is used as a post biological treatment to remove odor and color from water. Chlorine molecules and molecules with carbon-sulfur bonds, which contribute to poor taste and smell, are easily adsorbed onto carbon (Simate et al., 2011). Activated carbon is made from a variety of materials including coconut shells, peat, coal, petroleum pitch, and agricultural wastes (Hao at al., 2014). Activated carbon is also used within in brewing processes that produce clear beers (Simate et al., 2011).

Microalgae reduce the organic load of wastewater and provide useful byproducts. Microalgae convert CO_2, nitrogen, phosphorous, and other nutrients present in brewery wastewater into biomass and oxygen using sunlight. The oxygen is used by bacteria which reduce the COD of the effluent. In a study by Luo et al. (2018) 78% of nitrogen and 92% of phosphorus was removed from piggery wastewater using microalgae. Travieso et al. (2008) showed that microalgae were capable of removing >98% of COD from a distillery effluent. Microalgae treatments are less costly than traditional treatment methods and require a lower energy input. Algal biomass from the treatment can be used as fertilizer, animal feed, or biofuel (Amenorfenyo et al., 2019). Some post treatment is needed to remove the algal biomass and produce high quality water.

Figure 11: An example of a microalgae treatment raceway pond. This configuration is used to optimize sunlight exposure (Breeden, 2017).

Wastewater Reuse

Drawing large quantities from a surface or groundwater water source may deplete the resource and have negative environmental impacts. If a brewery draws water directly from groundwater or surface water supplies, it must treat the water prior to use to produce high quality beer. Additionally, the breweries that discharge large quantities of partially treated or untreated water to nearby water bodies have a huge impact on the environment. Thus, it is beneficial to both breweries and the environment to treat and reuse brewery wastewater. Breweries can generate their own high-quality water for their brewing process, limit the amount of water they draw from natural sources, and limit the amount of wastewater they discharge into the environment by implementing a comprehensive treatment method. This may be a combination of those described in Wastewater Treatment Section.

Breweries can reuse water within the brewing process even before treatment, because not all steps require high quality water. Cleaning water contributes up to 97% of total wastewater volume in breweries, but only contains around 3% of the total BOD ((Simate et al., 2011). Cleaning water containing detergents can be transferred from different cleaning operations and reused as a way to cut down on water and cleaning chemicals. The strength of the cleaning solution being reused is measured by using a pH meter to make the detergent concentration is still appropriate (Brewers Association, 2016). Weak wort can be reused in the next brew's mashing section. This reduces the amount of water consumed per brew and the COD levels of the effluent (Xhagolli et al., 2010).

Wastewater Reduction

In many communities, breweries may be the single largest consumer of water and producer of organic effluent (Brewers Association, 2016). Reduction of water usage goes hand in hand with reuse and treatment—reusing water reduces the total amount consumed and reducing water use limits the total amount of treatment needed. According to the Brewers Association Manual on Water and Wastewater: Treatment/Volume Reduction, there are five general methods to reduce water usage in breweries: adjust water flow, modify existing equipment, use more water-efficient equipment, reuse/recycle water, or shift to low-water or waterless processes.

Performing a water balance on each step in the brewing process is a technique to quantify overall water usage and identify potential reduction areas. Installing water flow meters at various places in the process can help identify water loss from leaks (Brewers Association, 2016). Replacing traditional cleaning operations with Clean in Place (CIP) systems greatly reduces water and chemical consumption and increases the cleanliness of the brewing operation. CIP systems use high-pressure spray balls at the top of brewing vessels to distribute water and sanitation chemicals in a vessel and can be designed to reuse wash solutions at various steps or recover them for future use (Pettigrew et al., 2015). A CIP system installed at Bell Brewery in Kalamazoo, Michigan reduced the amount of water used to clean the brewery's tanks by 65% (Brewers Association, 2016).

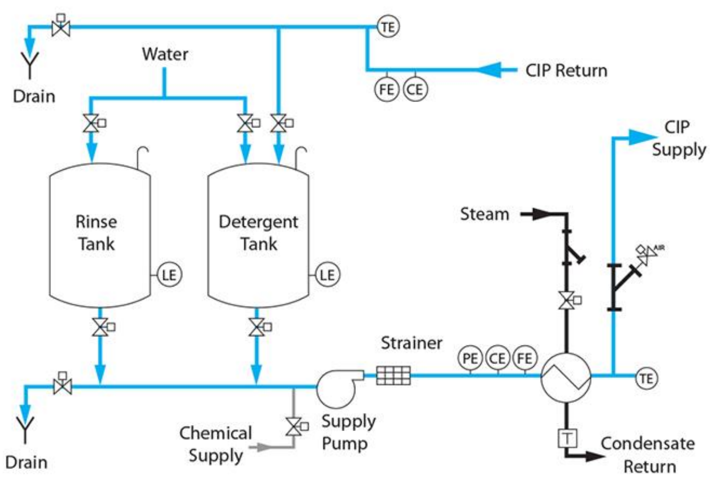

Figure 12: Schematic of a two tank CIP system. Cleaning solution is cycled between brewery tanks and CIP rinse and detergent tanks (Sani-Matic, n.d.).

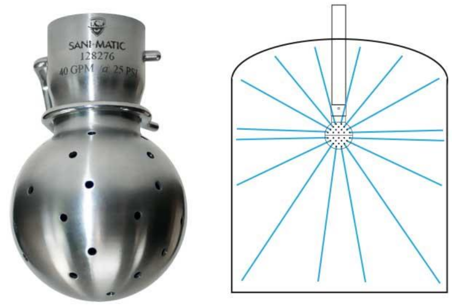

Figure 13: An example of a CIP system spray nozzle used inside of brewing tanks (Sani-Matic, n.d.).

A closed loop heat exchanger used to cool brewery fermenters can reduce water usage by more than 90% compared to a single pass heat exchanger (Brewers Association, 2016). Water usage has the potential to be reduced in many other areas of the brewing process, including packaging, cask, keg, and bottle washing, cooling towers, and steam boilers (S. Kmiotek, personal communication, September 05, 2019).

Solid Waste Use

Not only is water important to the brewing process, but the grains, yeast and hops added to the beer also play an important role in terms of waste. From providing the fuel for the fermentation, to flavors and the baseline of the process, solids are utilized and are one of the largest components generated in the process. In terms of brewers spent grain, about 74-78% of protein in the grain remains in the waste after the milling process, so it is high in quality protein (Farcas et al., 2017). Farmers often use it for animal feed, but when the grain is processed the uses expand to different industries. Through hydrolysis the grain products are used in the food industry for emulsifying agents and flavor binding, as well as the production of valuable enzymes and organic acids. The hydrolyzed grain can also be hydrothermally treated for use as a carbon filter (Hao et al., 2014). Further processing can yield monosaccharide products such as xylitol, which is a sugar alternative. If the grain is not chemically reduced, it can be dried and used for flour in baking or even as an animal protein substitute in certain sausages. Investigation into the use of spent grain as a raw material for nanofiber production is currently underway, where the industry uses range from medical to cosmetic (Farcas et al., 2017) (Mussatto et al., 2006).

The solid product that appears next in the beer brewing process is the spent yeast. By collecting it from the fermentation and storage tanks, brewers often concentrate the yeast to prevent the loss of product (Farcas et al., 2017). Yeast contains over 40% protein and a use includes animal feed supplements (Brewers Association, 2016). Spent yeast is high in a variety of quality protein, comparable to soy protein on today's market. The spent yeast contains something called monosodium glutamate, which is known to have an "umami" flavor similar to the flavors of meat, making it valuable as a meat flavor substitute. With processing, the spent yeast is broken down into β-glucans, which are sugars found in the cell walls of the yeast. β-glucans are used in both cosmetics and the food industry, and the European Food Safety Authority approved it for use as a new food ingredient. Due to the yeast's high salt content direct uses in foods is limited (Farcas et al., 2017) (Mussatto et al., 2006).

The last of the solid wastes includes the spent hops and trub, where 85% of the hops material ends up as a waste product. The spent hops and trub generally cannot be used directly as animal feed because it contains the chemicals that, at high concentrations, can induce hypnotic and sedative properties if consumed. Due to these limitations it can only be mixed with spent grain in smaller quantities and sent to be animal feed. Another popular use includes being a fertilizer or soil conditioner, as hops and trub contain a high nitrogen concentration. Newer uses include processing the waste through oxidation or hydrolysis, where the products can be used as a safe way to control bacteria in ethanol fermentations and organic acids (Farcas et al., 2017).

2.5 Incentives for Improved Brewery Waste Management

Reduction of Operation Costs

Reusing brewery wastes reduces operation costs and increases overall profits. The cost of using water in a process includes more than just the price of raw tap water. Water must be pretreated, moved, heated, cooled, and treated again after use. These processes require energy and chemical inputs that greatly increase the total cost of using water. The quality of water used can also impact the quality and profitability of the beer product. Reusing and recycling water when appropriate helps reduce operational costs by decreasing energy and chemical inputs. Initial costs for installing treatment methods can be high, but subsequent savings typically offset the initial cost. For example, Bass Brewers in Bedfordshire, England improved their cask washing process by redesigning their spray nozzles and recovering final rinse water for other uses. The initial investment was £95,350, but total annual savings were £86,900/year (Brewers Association, 2016). With small amounts of maintenance in the future, the system will continue to reduce operational costs for years to come. Another brewery in Manchester, England called J W Lees & Co's installed new float valves in their tanks to minimize the overflow of hot liquor into drains. The cost of the valves was £2000 but this was offset by £5000 per year saved in water, energy, and lost product (Brewers Association, 2016).

Reusing spent grains and yeast from the brewing process is another method to reduce operational costs. Spent grains can be sold as fertilizers or animal feed supplements. In some areas of the U.S., spent grains are simply donated to farmers because giving them away is cheaper than paying for disposal (S. Kmiotek, personal communication, September 05, 2019). Given that the alcohol content in beer never reaches a sufficient level to kill the yeast, there is potential for it to be reused in the brewing process. (S. Kmiotek, personal communication, September 05, 2019). Spent grains are frequently used by bakeries as a nutritious replacement for other grains. Using brewery waste to produce biogas or electricity as discussed in the Wastewater Treatment Section can also offset operational costs.

Product Branding

In a 2009 survey by Globescan and Circle of Blue, more than 90% of the 32,000 people polled saw water pollution and freshwater shortage as serious issues. Consumers are more willing to invest in products that have an extended impact, and companies can "tap into significant market niches by offering customers water-efficient choices and solutions" (Brewers Association, 2016). Product branding is a feasible way to encourage beer brewers to increase sustainability in their brewery. One example in the United States is Green Seal. Green Seal is a national, nonprofit organization founded in 1989 that certifies products and services that meet their set, strict standards for human health and reduced environmental impact. Sanya et al., affiliated with the School of Public and Environmental Affairs at the University of Indiana (2018), argues that through numerous tests and observations, consumers in the United States are "willing to pay a premium for sustainably brewed beer" (page 3). While this particular study has not been conducted in Albania, through interviews and more research, discussed in detail in our methods chapter, Albanians could feel similarly. Therefore, Albanian brewers could charge more money for their sustainably brewed beer and increase their profits. These seals, or brandings, would appear on the beer's packaging or labeling, in clear view for the customers. This form of positive advertisement would encourage consumers to purchase their beer over other, non-sustainably brewed beers.

Environmental Footprint

While the major public concern of beer breweries has traditionally been about wastewater pollution, air pollution, solid wastes and energy usage also contribute to beer breweries environmental footprint (Olajire, 2012). As discussed previously, wastewater pollution produced by beer breweries inflicts serious harm on aquatic ecosystems and, along with air pollution, tend to generate greenhouse gas emissions. Solid wastes tend to attract numerous pests and rodents and if not handled correctly, could become a breeding ground for microorganisms (Thomas & Rahman, 2006). Reducing their environmental footprint and making an effort to focus on public health implications of these byproducts may encourage consumers in Albania to purchase one product over others.

Employee and Customer Engagement

Employees become more engaged with their employer when they feel they are making a measurable positive difference within the company or their community. Integrating sustainability goals into a company mission engages employees and develops their sense of loyalty and pride for the company (Jones et al., 2008). Integrated reporting methods allow companies to iteratively set sustainability goals and communicate the accomplishment of these goals with customers and stakeholders (James, M. L., 2013). Employees who are included in the development of these goals think more innovatively and maximize their own skill sets, creating value in the company (Tomšič et. al., 2015). Employees are investors in and advertisers for a company. Employees who support their company's mission to communicate this support to customers through employee-customer interactions, which can include company outreach campaigns or simply relationships employees have with members of their community (Jones et. al., 2008). Customers often see sustainability initiatives as a desirable attribute in a company because they feel their purchase is making a difference either locally or nationally, making them more loyal to the brand.

2.6 Stakeholders

Key stakeholders in this project are SHUKAlb, the Albanian government associations that regulate wastewater, the Albanian brewers, and the consumers of the beer. SHUKAlb has developed this project to assess how Albanian breweries currently manage their waste, how breweries impact the environment, and determine where improvements can be made. SHUKAlb is interested in identifying feasible incentives for Albanian breweries to improve their waste management practices. The company has expressed interest in using this project as a starting point for future projects in improving water management among industries in Albania.

There are many incentives for breweries to improve their waste management practices, and this project intends to identify those incentives that are applicable to Albanian breweries. Some waste treatment, reduction, and reuse methods may be more applicable to some breweries than others, but all breweries have something to gain by making their processes more environmentally friendly. By implementing these sustainability initiatives, brewery employees have the opportunity to become more involved with their brand and work towards a goal that benefits the company, the environment, and surrounding communities.

Albanian beer consumers are stakeholders in this project because they play a role in determining the feasibility of implementing large scale sustainability initiatives. Funding for these initiatives is generated by consumers' interest and willingness to monetarily support the brewery. Consumers are also part of the Albanian public that could experience improved water quality and less polluted environments if breweries make their processes more environmentally friendly. Lastly, local farmers and bakeries may have the opportunity to develop a mutualistic relationship with breweries by reusing spent grains.

Thousands of hectoliters of brewery wastewater are sent into bodies of water in Albania every year. Huge quantities of solid brewery wastes are produced and disposed of in unregulated sites. This presents a specific occurrence of pollution that can be studied and quantified, which may help develop future studies on other sources of pollution. Controlling the disposal of beer waste is just one step out of the many to create a more environmentally and socially sustainable Albania.

3. Methodology

The goal of this project is to assess how breweries in Albania dispose of their waste and to make recommendations to improve brewery waste management. Improvements in brewery waste management could reduce the impact breweries have on the environment and improve the quality of natural water sources in Albania. Improvements could also lower brewery operating costs, increase profits, and increase employee, customer, and stakeholder engagement. The team will develop a set of recommendations and compile research and incentives in an accessible form for both Albanian breweries and SHUKAlb. Our research objectives are as follows and the flowchart below (see Figure 1) illustrates how they overlap with our planned methods:

- Assess wastewater systems in areas surrounding breweries to assess the collection, treatment and disposal of sewage waste in relation to the breweries
- Assess current waste management practices at breweries and estimate what impact beer wastes have on local environments.
- Assess what sustainability initiatives could reduce operational costs for breweries.
- Establish incentives for brewers to change their current waste management practices.

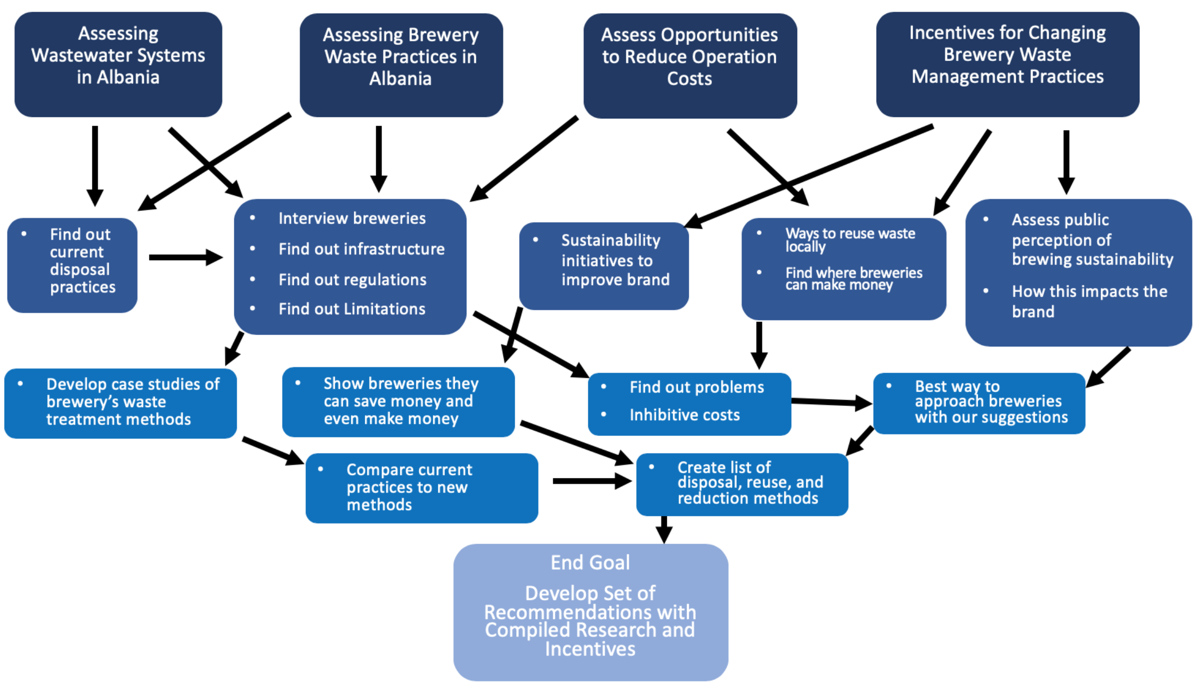

Figure 14: Objectives and Goal Chart

3.1 Assessing Wastewater Systems in Albania

We will examine current water supply and waste treatment infrastructure and brewery waste management practices in Albania. We will collect data for this case study by interviewing members of SHUKAlb and other organizations related to water infrastructure and reviewing Albania's regulations on waste disposal. Wastewater experts have valuable experience regarding waste regulations for various industries and current trends with respect to waste disposal. These interviews shall address challenges of regulating industries and how practices are monitored. This approach will connect government regulation, municipal infrastructure, and brewery practices to provide a full picture of current waste management practices in Albania as it relates to downstream brewery waste.

This investigation will use purposive sampling to select interviewees from the water infrastructure sector. Organizations we will include in our interviews are SHUKAlb, the Polytechnic University of Tirana, and the Albanian Water Regulatory Authority (WRA). At SHUKAlb, the group wants to interview a member of their technical committee. For the Polytechnic University of Tirana, the team plans on interviewing a member of the Department of Environmental Engineering in the Faculty of Civil Engineering, as well as a member of the Department of Climate and Environment in the Institute of Geosciences and Energy, Water and Environment. Finally, for the WRA, the team wants to interview a member of the Technical and Economic Directorate within the organization. This will provide the team with information from a variety of sources such as academic and industry to assess the wastewater systems from different viewpoints.

The team will contact candidates ahead of time to confirm their participation and to make them fully aware that any information collected will be used for project purposes only and proprietary information shall be kept confidential. Interviews conducted follow the informed interview script outlined in Appendix 1. We will also provide any interviewees with full access to our work at the end of the project. These interviews will address the following questions:

- How is water distributed and treated in Albania?
- What are the regulations for waste disposal in Albania?
- Are breweries connected to municipal water systems?
- Are breweries connected to municipal solid waste disposal networks?
- What are the challenges in regulating an industry?
- What prevents industries from complying with regulation?

Interview questions for water sector organizations can be found in Appendix 2. Data analysis includes identifying frequent responses and key themes from interviews with the infrastructure experts.

This will illuminate water distribution and treatment infrastructure functions within Albania and where current issues lie.

3.2 Assessing Brewery Waste Practices in Albania

To meet our goal of providing accurate, useful information to Albanian breweries and SHUKAlb, current brewery waste treatment and disposal practices must be assessed. The team will research government regulations on waste management in Albania to determine what laws are already in place. We will also interview brewers to learn about their practices concerning waste disposal as a part of our case study. We expect to work alongside microbreweries for the majority of our project because they are not yet well established in the beer market and may be looking for strategies to improve their business. Brewers will have the best information regarding the challenges breweries face regarding their own waste. Determining what aspects of breweries need the most improvement may help establish incentives for improved practices, and patterns regarding inefficiencies may become apparent. Ideally, we want to visit at least three of the five larger breweries and at least five microbreweries in different regions. Convenience sampling will be used to determine which breweries are included in the case study.

The team will use photo documentation during brewery tours to assess current brewery practices. Visual documentation of Albanian brewery processes can compare infrastructure to other breweries that have implemented sustainability initiatives, including those we have toured in the United States. The next step involves creating process flow charts for how each brewery operates. Photos taken shall follow the shooting script below (Rose 2012):

- What does the area surrounding the breweries look like?
- What advantages or disadvantages are there to the environment around the breweries?
- Where are the current places waste leaves the facility?
- What equipment does the brewery currently have and what state is it in?
- Does the brewery have any established waste infrastructure?

Brewery interview candidates shall be contacted ahead of time to confirm their participation and to make them fully aware that any information collected is for project purposes only and proprietary information will be kept confidential. Interviews conducted follow the informed interview script outlined in Appendix 1. Full access to our work at the end of the project shall be provided to interviewees. These interviews will address the following questions (see Appendix 3 for detailed questions):

- How are Albania breweries disposing of their waste?
- How much wastewater and solid waste do Albanian breweries produce?
- What are the largest costs for infrastructure?
- What is preventing breweries from properly disposing of their waste?
- What are the largest challenges regarding brewery waste disposal?
- What prevents breweries from following the regulations?
- What incentives would make breweries follow the regulations?

We will group the breweries in stratified samples based on the relative size of the brewery: large or small. This data will allow the team to assess how practices differ between small and large breweries, and to identify possible patterns within each respective population and then between them.

3.3 Assess What Sustainability Initiatives Could Reduce Operational Cost for Breweries

To assess what sustainability initiatives can reduce operational costs in breweries, the team will research waste treatment, reduction, and reuse methods adopted by breweries around the world. We will consult budget results, company websites, and academic articles to obtain information on implementation costs and operation cost reductions. Brewery visits and interviews with brewers in the New England area will provide additional data on the costs, challenges, and benefits of implementing and maintaining waste treatment processes. This research will be entered into a table and organized by type of initiative (i.e. water use reduction, energy use reduction, water reuse). An example table is shown in Appendix 6. This data shall provide an overview of what methods breweries worldwide have adopted to reduce their environmental impact and how those methods have impacted their operation costs. We hope to answer the following questions through this research:

- What is the cost of implementing various brewery waste treatments around the world?
- How have other breweries reduced their operational costs by implementing waste treatment, reduction, and reuse operations?
- What steps have breweries in New England taken to reduce their environmental impact and how has that impacted their costs and profits?
- How does this research apply to Albanian breweries?

Having this information ready and available for Albanian brewers will provide them insight into how improving their waste management can increase their profitability. The team would also like to review budget reports and operating costs from Albanian breweries, but it may be difficult to obtain this information. The smaller breweries may be more willing to share information about their operating costs because they may be more interested in learning about ways to improve their processes. Should breweries provide their information, we will conduct a cost-benefit analysis. An example cost-benefit analysis is presented in Appendix 7. We hope that this will help Albanian brewers see the cost incentives associated with sustainable waste treatment and encourage them to make the necessary changes to implement them.

3.4 Establish Incentives for Brewers to Change Their Waste Management Practices

As noted in our background chapter, breweries are generally willing to implement sustainability initiatives if they can increase their profits, reduce their operation costs, and/or engage their consumers and stakeholders (Section 2.2.5). To determine possible incentives for breweries to change their waste management practices, this investigation will analyze results from the previous three objectives and compare them to topics discussed in the background chapter.

Investigating how the Albanian beer consumers perceive brewery waste management and sustainability initiatives is an important aspect of this project. Breweries may be able to charge more for beer that is more sustainably brewed and occupy a unique niche in the beer market, but this is only feasible if consumers are aware of the environmental impacts of beer brewing and value the sustainability of the beer they purchase.

This investigation will use a semantic differential scale survey to determine what drives beer consumers to buy certain brands over others. Semantic differential scales measure attitudes towards a certain topic and present this data in a quantitative form (Semantic Differential Scale: Definition, Examples, 2016). The team will visit stores that sell alcohol, restaurants and local bars in Tirana to distribute the surveys to consumers or owners of businesses that sell beer. This investigation will use purposive sampling to select interviewees from the local businesses. The sample shall include restaurants and bars of varying age and customer base. With the help of our sponsor, we will either email or visit each location in advance to obtain permission to conduct surveys at each facility.

This survey will ask participants to rate the importance of aspects such as price, taste, packaging, and sustainability. The survey will also include several questions to record the demographics of the survey group (age, gender, amount of beer consumed weekly). An example can be found in Appendix 6. The team will also distribute a separate survey of the same format to business owners to gauge their attitudes towards serving more sustainably brewed beer. Participants will be given the survey in both Albanian and English and a translator will accompany the team to distribute the surveys. The survey data will then be tabulated and compared to determine patterns from consumers when they purchase beer and to businesses selling beer.

- These incentives will be a large part of our final deliverable to SHUKAlb and breweries that participated in our research. Questions the surveys will address are:
- Are Albanian consumers willing to pay more for sustainably brewed beer?
- Can sustainability initiatives make a brewery more marketable and competitive than others?
- Can sustainability initiatives improve employee, customer, and stakeholder engagement with the brewery?

Additionally, if time allows, this project will include interviewing local bakeries and farmers on the possibility of reusing solid brewery wastes. This is potentially a mutualistic partnership between both brewers and farmers and provides another incentive for breweries to adopt a more sustainable waste management model. Questions we want to address include:

- Are there local bakeries that could partner with breweries to reuse spent grains?
- Are there local farmers that could partner with breweries to reuse spent grains?

We would contact these individuals in advance, either through email or phone calls, to gain permission to meet with them. The information gathered from these interviews will be analyzed to reveal themes and popular processes that would be applicable to beer breweries in Albania. Identified trends will be compared to data from brewery interviews to determine if there are opportunities for forming relationships between local farmers, bakeries, and breweries. Interview questions for farmers and bakeries can be found in Appendices 4 & 5.

3.5 Analysis and Overview of Methods

The analysis of the data will allow the group to find any trends that may have the greatest impact on mitigating the environmental impacts of brewing beer. The end of each week will include a summary and classification session. The group will review all data collected and inform other members of key research or important points. This will allow the group to familiarize themselves with the data and records the group member’s first impressions that can’t be obtained later on in the term. It will also help to identify areas of research that are not addressed by the planned methods. Adjustments to our methods will be made if this occurs.

Towards the end of the term when the majority of the data has been collected, and all interviews for particular stakeholders are finished, the larger analysis will occur. The team will work to establish patterns and find connections between established categories. This will allow the team to see relationships and define the relative importance of the collected data as a whole. The final interpretation of the analysis will lend itself to the development of the SHUKAlb deliverable, where the outline and key points of research can be clearly observed (Taylor-Powell & Renner, 2003).

The methods by which the group plans to accomplish the objectives have many overlaps, as seen in Figure 1, in the objectives flowchart. The three overarching themes of research, visiting breweries, and interviewing members of the Tirana public have emerged from our methods. The following flow chart indicates what will be completed under each overarching theme.

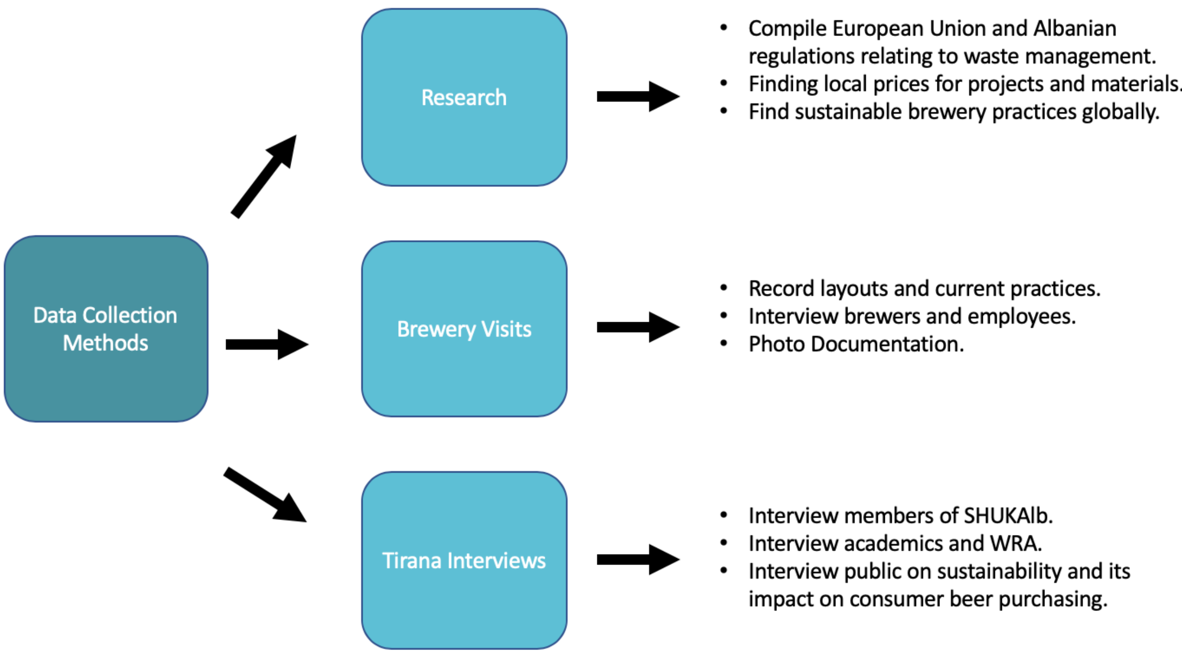

Figure 15: Data Collection Methods

All of our data will be placed into a multiple-case study. A multiple-case study is the best option for our project because we will be exploring multiple cases and compiling them to identify industry trends. We will review each interview and identify key themes (i.e. cost, infrastructure, convenience) between the challenges faced by each brewery (Baxter & Jack, 2008). Through our research, we will also group the breweries based on these independent variables: size, location, and proximity to major cities and analyze their responses with respect to these categories. By examining the disposal practices and challenges faced by some selected breweries in Albania, we will identify similarities, differences and patterns, and use this to better understand the challenges faced from our convenience sample. These can then be compared to breweries we have toured and read about in the United States and other countries. The final deliverable for this project includes two separate booklets of our findings: one for the brewers in Albania and one for SHUKAlb. These booklets will outline the findings and provide relevant information that's accessible to each respective organization.

The Gantt chart in Figure 3 shows the project timeline. The group will complete initial research and comprehension of current conditions in the first two weeks. The middle of the term consists of visiting breweries and conducting relevant interviews. In the last third of the term, the team will determine incentives and interview consumers, then develop the final deliverables.

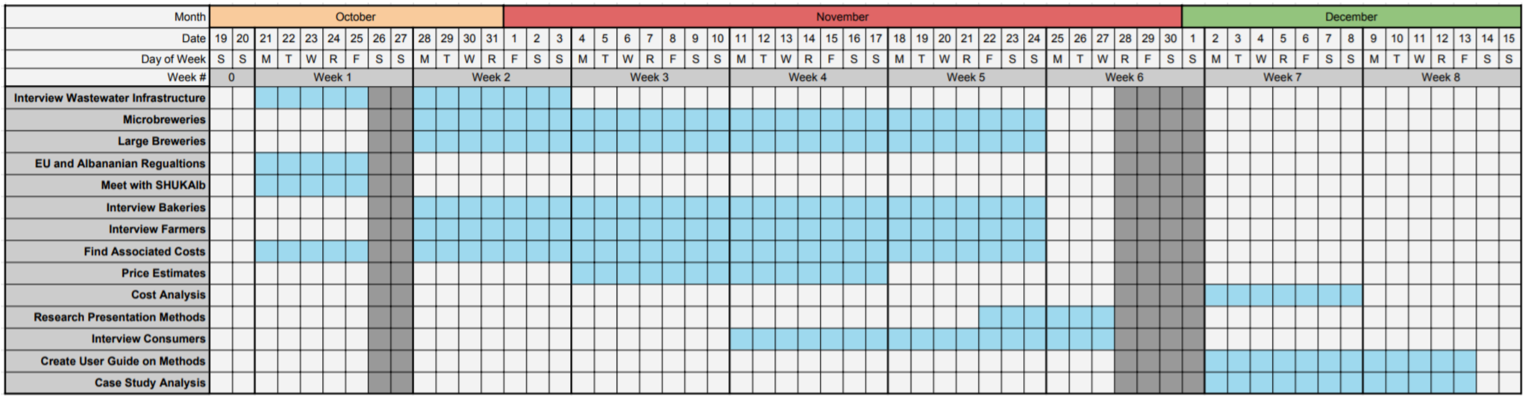

Figure 16: Gantt chart for research timeline while in Albania.

Appendices

Appendix 1: Informed Consent Script

Considerations:

- Remain neutral on the subject. Ask open ended questions that are not leading in any way.
- Make sure the interviewee is aware they can remain anonymous if they choose. This will hopefully ensure their answers are honest.
- If the interviewee appears to be uncomfortable with a question, do not pry, just move to the next question.

Introduction:

Hello _______. We are American students from Worcester Polytechnic Institute doing a research project on reducing the environmental impacts of brewing beer. We are working with SHUKAlb, an organization that deals with water supply and wastewater management. We would like to interview you on ______________________. If it's okay with you, could we get your permission to record this interview on our phones to make sure we capture your responses? If you would rather not, it's perfectly fine, we can just take notes instead. Any information you share with us is completely confidential and will only be used for research purposes with your permission. Do we have your permission to quote you in our report? You have the option to remain anonymous. We will not identify you by name in any of our writing to make sure the information you share with us is confidential, unless you would like to be quoted.

Our report will summarize brewery waste management practices in Albania and make recommendations on how to improve these practices. Our recommendations aim to reduce the environmental impacts of brewing beer by reducing, reusing, and recycling beer waste products. It will be available online after we finish writing it, and we can also email it to you if you wish. If we ask a question that you do not want to answer, just let us know and we will move to the next one. If you don't understand our question, let us know and we can try to rephrase. Do you have any questions for us before we begin?

Date/Time: ______________________

Location: ______________________

Interviewers: ______________________

Interviewee: ______________________

Interviewee Role: ______________________

Question	**Yes**	**No**
Do we have permission to record this interview?		

Would you like to be confidential, or can we use your name and quote you in our report?		
Would you like us to share our paper with you when it is complete?		

Interview Questions:	**Notes on Response:**
Q(N)	
Q(N+1)	

Conclusion:

Thank you for talking with us today and for participating in our research! Was there anything in the interview that you think we missed or wish we would have talked about more? Do you want to review our notes and transcript of the interview? Is there anything else you would like to add? You can always reach us at (emails/phone numbers) and you can also contact SHUKAlb to ask for us (contact info). Thank you for your time.

Appendix 2: Interview Questions for Water Sector Organizations

1. What is your role within your organization?
2. How long have you worked for your organization?
3. Have you noticed any trends regarding compliance amongst breweries and other large corporations? Any trends regarding waste discharge?
4. How were these regulations developed?
5. How long have these regulations been in effect?
6. How was disposal regulated before these were put in place?
7. What are the challenges associated with regulating wastewater and solid waste disposal (spent grains, yeast, hops)?
8. How does Albania's current wastewater waste treatment infrastructure pose a challenge to follow regulations?
9. Are you familiar with beer breweries and how well their practices follow these regulations?
10. What percentage of businesses/industries are connected to municipal water systems?
11. What do you feel would be the most impactful change, regarding cost, that could be implemented to improve their infrastructure?

Appendix 3: Interview Questions for Brewers

1. When was the brewery founded?
2. What types of beer is produced here?
3. How large is your brewery approximately?
4. How much volume of beer does the brewery produce per year?
5. How long have you worked at the brewery?
6. What type of training have you had (i.e. apprenticeship, college education)?
7. What types of wastes does the brewery produce?
8. What parts of the brewing process produce wastewater and solid waste?
9. How does the brewery dispose of wastewater?
10. What do you do with your solid wastes?
11. Do you treat any of your waste products before disposing of them?
    a. If yes, how?
12. Where do you draw water from for the brewing process?
13. Is the brewery connected to a municipal water system?
14. Is the brewery connected to a municipal solid waste disposal system?
15. What are the current challenges associated with disposing of brewery wastewater and solid waste?
16. What are the impacts of your waste management practices on the surrounding area?
17. What are the costs associated with disposing of brewery waste?
18. What is the most expensive aspect of disposing your waste? Roughly how much does this cost?
19. Do you know what other breweries do with their wastewater and spent grains?
20. What incentives would encourage you to implement more sustainable practices?
21. Have you ever heard of any waste treatment, reuse, or reduction methods in breweries?
    a. If yes, which ones stuck with you the most and why?

Appendix 4: Interview Questions for Farmers

1. What do you currently use for fertilizer and/or animal feed?
2. How and where do you get your fertilizer/animal feed?
3. Have you experienced any issues regarding reliable feed sources? If so, what?
4. How feasible would it be for you to partner with a local brewery to use their spent grain as fertilizer/animal feed?
5. Do you currently pay for animal feed? If so, how much?

Appendix 5: Interview Questions for Bakers

1. What types of grains do you use in your bread?
2. Have you ever heard of using spent grains from brewing beer in bread making? What have you heard about this?
3. What would make you consider using spent grains in some of your products?
4. How feasible would it be for you to partner with a local brewery to reuse some of their spent grain?

Appendix 6: Sustainable Process Research Chart

Brewery Name, Size, Location	Type of Change	Reason for Implementation	Summary of Implemented System	Cost to Implement	Return on Investment	Reduction of Operating Cost
	Water Treatment Water Reuse Water Reduction Energy Reduction etc.	Regulations Cost Savings Process Optimization Sustainability				

Appendix 7: Example Cost-Benefit Analysis

Machine Type	Fiscal Year		
Costs	2018	2019	Total
Initial Machine Cost			
Cost of Labor			
Costs of Materials			
Cost of Maintenance			
Total			

Benefits	2018	2019	Total
Profit			
Total			

Analysis	2018	2019	Total
Cost-Benefit Ratio			

Appendix 8: Semantic Differential Scale Survey for Beer Consumers

Age	________________
Gender	________________
How many times per week do you consume beer	________________

Circle one number per row, from 1 to 9: 1 being the least important, and 9 being the most important to you. If you would prefer to not answer a question, leave it blank and move on to the next one.

Taste	Not Important	1	2	3	4	5	6	7	8	9	Very Important
Price	Not Important	1	2	3	4	5	6	7	8	9	Very Important
Packaging	Not Important	1	2	3	4	5	6	7	8	9	Very Important
Sustainability	Not Important	1	2	3	4	5	6	7	8	9	Very Important
Branding	Not Important	1	2	3	4	5	6	7	8	9	Very Important
Advertisements	Not Important	1	2	3	4	5	6	7	8	9	Very Important
Local Ingredients	Not Important	1	2	3	4	5	6	7	8	9	Very Important
Popularity	Not Important	1	2	3	4	5	6	7	8	9	Very Important

Appendix 9: Authorship Page

Section	Author
1.0 Introduction	All Members
2. Background	Katy Jessop
2.1 Growth of Beer Production in Albania	—
History of Beer in Albania	Griffin St. Onge
Today's Albanian Breweries	Griffin St. Onge
Economic Impacts	Griffin St. Onge
2.2 Environmental Impacts of Brewery Waste	Sarah Boermeester
The Brewing Process	Sarah Boermeester
Wastewater	Marissa Gonzales
Solid Waste	Sarah Boermeester
2.3 Albanian Infrastructure to Dispose of Brewery Waste	Katy Jessop
2.4 Reuse, Treatment, and Reduction of Brewery Waste	—
Wastewater Treatment	Katy Jessop
Wastewater Reuse	Katy Jessop
Wastewater Reduction	Katy Jessop
Solid Waste Use	Sarah Boermeester
2.5 Incentives for Improved Brewery Waste Management	—
Reduction of Operation Costs	Sarah Boermeester
Product Branding	Marissa Gonzales
Environmental Footprint	Marissa Gonzales
Employee & Customer Engagement	Katy Jessop
2.6 Stakeholders	Sarah Boermeester and Katy Jessop
3.0 Methodology	—
3.1 Assessing Wastewater Systems in Albania	Katy Jessop
3.2 Assessing Brewery Waste Practices in Albania	Griffin St. Onge
3.3 Assess What Sustainability Initiatives Could Reduce Operational Cost for Breweries	Marissa Gonzales
3.4 Establish Incentives for Brewers to Change Their Waste Management Practices	Sarah Boermeester
3.5 Analysis and Overview of Methods	Sarah Boermeester
Appendices	—
Appendix 1: Informed Consent Script	Katy Jessop

Appendix 2: Interview Questions for Water Sector Organizations	Marissa Gonzales and Katy Jessop
Appendix 3: Interview Questions for Brewers	Griffin St. Onge
Appendix 4: Interview Questions for Farmers	Sarah Boermeester
Appendix 5: Interview Questions for Bakers	Katy Jessop
Appendix 6: Sustainable Process Research Chart	Katy Jessop
Appendix 7: Example Cost-Benefit Analysis	Marissa Gonzales
Appendix 8: Semantic Differential Scale Survey for Beer Consumers	All Members

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