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

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WATER SUPPLY AND SEWERAGE ASSOCIATION OF ALBANIA

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

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ABSTRACT

Breweries produce tons of organic solid waste and millions of liters of wastewater. When discharged into the environment without treatment, these waste streams degrade aquatic ecosystems and can pose risks to human health. Working with SHUKALB, our team investigated Albanian brewery practices and identified process improvements to reduce operating costs and breweries' environmental impact. Our interviews with industry professionals, extensive on-site assessment, and surveys demonstrate that general Albanian brewery processes compare favorably to global breweries except for a higher environmental impact due to no available industrial wastewater treatment in Albania. As costs influence brewery changes, we generated high-level recommendations for breweries to improve their environment impact.

EXECUTIVE SUMMARY

CONTEXT

The 2017 United Nations World Water Development Report estimates that the countries of the world discharge over 80% of their wastewater into the environment without treatment. In Albania there are only ten urban wastewater treatment plants (WWTPs), three of which are not in operation due to a lack of technical and financial support. The remaining treatment plants have the capacity to treat approximately 25% of the country's wastewater (United Nations Economic Commission for Europe, 2018). The Albanian government is currently focused on developing urban wastewater systems, so industrial wastewater treatment may not be available for years to come.

One of the most influential steps the country of Albania can take to protect its natural resources is to treat its urban and industrial wastewater. SHUKALB, or the Water Supply and Sewerage Association of Albania, is a professional organization that advocates for improvements and investment in Albanian wastewater infrastructure. SHUKALB has developed several initiatives to educate the public and assess current practices. Our project on assessing the environmental impact of brewery waste is a part of these initiatives.

Volumetrically, beer is the third most popular alcoholic beverage in Albania behind wine and raki, and beer consumption is increasing in Albania. The beer brewing process (see Figure E.1 below) produces multiple waste streams that have the potential to significantly harm the environment. The largest waste stream is wastewater. On average, breweries use between three and ten liters of water for every liter of beer they produce. Brewery wastewater contains cleaning chemicals, which impact the effluent's pH and chemical composition. It also has a high organic content, as it contains various amounts of brewing solids. The brewing process produces solid waste in the form of spent grain, spent yeast, hops, and trub. If a brewery does not treat its wastewater or solid waste before discharging it to the environment, the chemical characteristics and high organic content of these byproducts can cause eutrophication in aquatic ecosystems and impact the quality of natural water resources that the public may interact with. As the Albanian brewing industry grows, beer breweries will become a more significant contributor to waste streams.

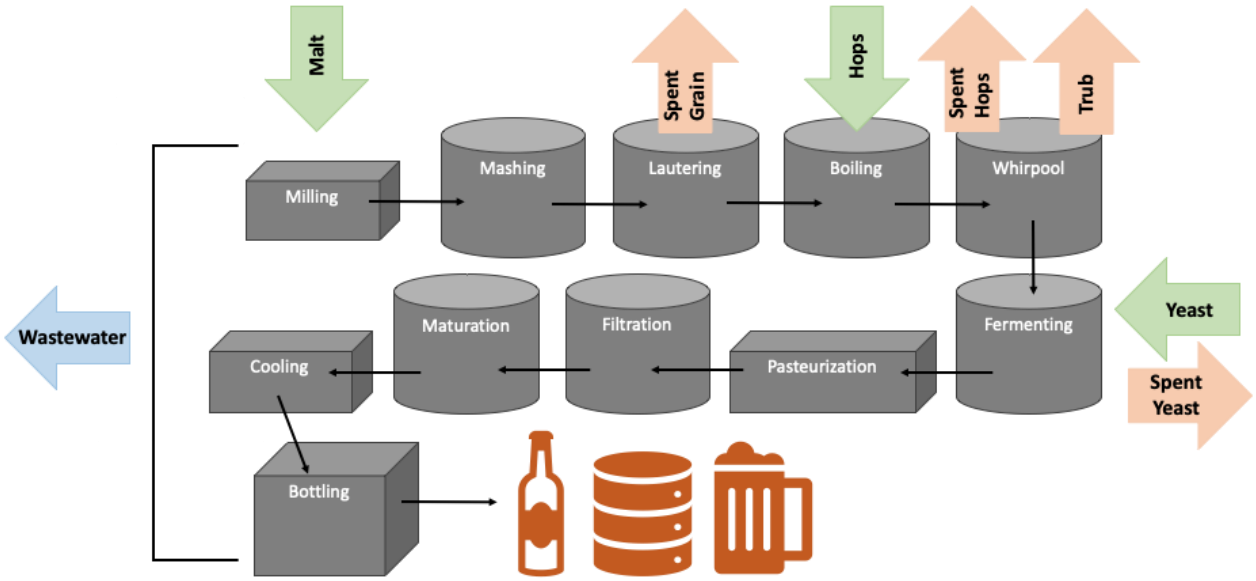

Figure E.1: Overview of brewing process

APPROACH

Due to the lack of industrial wastewater treatment in Albania, breweries have a greater responsibility to find alternative methods to treat their wastewater and dispose of their solid wastes in a manner that protects the natural resources around them. The goal of this project was to evaluate how Albanian breweries manage their waste, and to identify options for breweries to improve their processes and reduce their environmental impact. By implementing more sustainable processes, breweries may reduce operating costs, increase profits, and increase employee and consumer engagement. To frame our research, the team developed four main objectives:

1. Assess wastewater systems near breweries to characterize the collection, treatment and disposal of brewery effluent.
2. Assess how sustainable production processes can reduce operational costs for breweries.
3. Evaluate current brewery waste management practices and their impact on the surrounding environment.
4. Characterize beer consumer purchasing preferences to determine if consumers value a more sustainably brewed beer.

To examine current water supply and waste treatment infrastructure, the team interviewed professionals from the wastewater sector. Interviews addressed the procedures and challenges associated with regulating brewery wastewater discharges. The team toured Albanian WWTPs to evaluate their water treatment technologies, how breweries connect to municipal systems, and to assess whether Albania's WWTPs are capable of treating brewery wastewater.

The team researched waste treatment, reduction, and reuse methods adopted by breweries in other countries to identify sustainable production processes that can reduce operational costs in breweries. Prior to traveling to Albania, the team visited and interviewed breweries in Massachusetts. The information gained from these brewery visits provided a baseline for the project and facilitated a comparison to Albanian breweries. This process generated examples of possible brewery waste management methods and informed the design of our questions for tours and interviews with Albanian breweries.

To evaluate brewery waste management practices, the team toured and interviewed seven breweries of varying scales across Albania, seen in Table E.1.

Table E.1: Brewery Interviews and Tours

Brewery	*Size*	*Location*	*Tour Date*
Bräuhaus	Pub	Tirana	Nov 11, 2019
Birra Stela	Large	Tirana	Nov 12, 2019
Birra Korça	Large	Korçë	Nov 15, 2019
Birra Tirana	Large	Tirana	Nov 19, 2019
Birra Kaon	Large	Tirana	Nov 19, 2019
Birra Puka	Micro	Pukë	Nov 21, 2019
Birraria e Gjyshit	Micro	N/A*	Nov 25, 2019

*Interview conducted in Tirana as they do not currently have a facility

During the brewery tours, the team requested to photograph the brewery's processes and used these photos to compare Albanian brewery processes to U.S. breweries. The combination of brewery tours, interviews, and photo documentation helped us characterize current Albanian brewery practices and identify where breweries can most significantly improve their practices to reduce their environmental impact. Our interviews with breweries also illuminated the factors, such as operation costs and market competition, that limit or drive Albanian breweries to invest in process improvements.

In the United States, breweries advertise their sustainable practices to market their product and consumers are frequently willing to pay more for a sustainably brewed beer. We wanted to know what factors influence how Albanians purchase beer and if a brewery's environmental impact had any role in it. The team believed that Albanian breweries may be more likely to implement environmentally friendly practices if they could engage their consumers by advertising these initiatives. To determine this, the team employed a five-point Likert scale survey, shown in Figure E.2. We asked consumers how much they agreed or disagreed with different factors of purchasing beer (i.e. price, packaging, sustainability), where zero indicates strongly disagree, two indicates neutral, and four indicates strongly agree.

SHUKALB distributed an online version of the survey to its general mailing list and the team distributed a paper version to customers at four bars in Tirana, listed in Table E.2. We chose bars through convenience sampling as we could only distribute surveys with the owner's permission. Additionally, our team interviewed management from the establishments to gauge their attitudes towards serving more sustainably brewed beer.

Table E.2: Bar and Restaurant Survey List

#	Title	Type	Interview (Y/N)	# of Surveys	Issue Date
1	Duff Sports Bar	Bar	Yes	19	11/12/19
2	Radio Bar	Bar	No	10	11/22/19
3	Cheers	Bar	Yes	16	11/23/19
4	Illyrian Saloon	Bar	Yes	28	12/2/19-12/6/19

Circle the age range that best describes you: 18-20 21-30 31-40 41-50 51-60 60+

Circle the gender that you identify with: Male Female Prefer not to answer

Circle the number of beers per week you consume on average: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15+

Based on the statements below, check one box to rank the level of which you agree or disagree with each statement. Only one ranking per statement. If you prefer not to answer a question, check the box that says "Not Relevant/Prefer Not to Answer" and move to the next statement.

Statement	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree		Not Relevant/ Prefer Not to Answer
I purchase a brand of beer because it costs less than other brands.	☐	☐	☐	☐	☐		☐
I purchase a brand of beer because I know it has a lower environmental impact than other brands.	☐	☐	☐	☐	☐		☐
I drink Albanian beer more than foreign beer because it was brewed in Albania.	☐	☐	☐	☐	☐		☐
I drink Albanian beer more than foreign beer because it is cheaper.	☐	☐	☐	☐	☐		☐
The design of the beer packaging influences what beer I buy.	☐	☐	☐	☐	☐		☐
I am more likely to drink beer that I see in advertisements on TV or around town.	☐	☐	☐	☐	☐		☐
I am more likely to buy a beer that uses local ingredients.	☐	☐	☐	☐	☐		☐
I am more likely to drink beer that my friends and family drink.	☐	☐	☐	☐	☐		☐

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Figure E.2: Paper Version of Consumer Survey

FINDINGS

Regulations are in place, but do not resolve Albania's industrial wastewater discharge problem.

Through the interviews with wastewater treatment professionals, the team found that breweries must maintain an environmental permit from the Ministry of Tourism and Environment to obtain a license to operate. This permit specifies how the brewery must treat, reuse, or dispose of its waste, and details the brewery's plans to manage materials and equipment. In the section of the document that requires breweries to communicate their plan to handle waste streams, they often list "no further treatment" as an acceptable response for wastewater discharges. The brewery must then coordinate with local authorities to properly dispose of its wastewater. Given the lack of industrial wastewater treatment infrastructure in Albania, breweries generally discharge their wastewater directly to the environment (Personal Communication, Ministry of Tourism and Environment, Nov. 26, 2019).

The vast majority of breweries cannot rely on municipal systems to treat their wastewater.

The team's interviews with wastewater professionals, along with tours of wastewater treatment plants (WWTPs) in Albania, illuminated that the vast majority of breweries cannot rely on municipal systems to treat their wastewater. We toured Vlorë and Korçë WWTPs to assess the current state of wastewater infrastructure in Albania. Vlorë WWTP is Albania's newest facility and it is still under development. Currently it only pretreats urban wastewater from the city of Vlorë; based on observation of the plant's effluent water, the team determined that it was not capable of treating brewery wastewater.

Korçë WWTP is Albania's most developed treatment facility. The plant currently follows Albania's wastewater regulations for BOD and COD discharge limits and treats wastewater from the city of Korçë and the nearby brewery, Birra Korça. This is the only instance of a brewery-WWTP connection in Albania. The operations of the remaining Albanian WWTPs, according to regulatory officials, fall closer to Vlorë WWTP than Korçë WWTP. Five of the seven breweries the team interviewed are located in Tirana, where there is no municipal wastewater treatment. We concluded that Albania's current WWTPs do not have the capacity or technology to treat brewery wastewater in addition to urban wastewater.

Water accounts for a high percentage of operating costs.

Touring breweries revealed that water is a large waste stream and operating cost for all Albanian breweries. In general, cleaning procedures consume the most water and result in large volumes of wastewater. Albanian breweries pay for both water supply and wastewater disposal. Even if a brewery owns a well, the government taxes the water drawn from it. In most cases, Albanian breweries filter or condition their water before use in the brewing process. All of the breweries claim this is the most expensive part of their brewing process, with Birra Korça stating that water accounts for 65% of its production costs.

Albanian breweries have implemented water reuse and reduction methods into their processes.

To reduce their water consumption and operating costs, the Albanian breweries have implemented water reuse and reduction practices. Five of the seven Albanian breweries have implemented clean in place (CIP) systems to cleanse their equipment. CIPs reuse caustic and acid cleaning chemicals, which reduces water consumption in the cleaning process. All Albanian breweries have installed low water consumption spray nozzles to clean their tanks. These nozzles increase water pressure and spray the cleaning solution in all directions to reduce the number of rinses necessary to clean a tank. Almost all Albanian breweries, except for Birra Puka and Birraria e Gjyshit, utilize closed loop heat exchangers. The breweries reuse the hot water produced from cooling boiled wort in the following batch. Lastly, Birra Kaon, Birra Tirana, and Birra Stela all recycle water within their pasteurization sections.

None of the seven Albanian breweries fully treat their wastewater before disposal.

Only three of the seven breweries we interviewed (Birra Korça, Birra Tirana, and Birra Stela) neutralize the pH value of their wastewater before discharge. None of the breweries remove organic material or suspended solids from their wastewater before disposal, and Birra Korça is the only brewery that sends its wastewater to a WWTP for further treatment. The remaining breweries discharge their wastewater directly to the environment.

Spent grain is the only recycled solid waste amongst Albanian breweries.

The team observed a mix of reuse and recycling procedures for solid waste. Nearly every Albanian brewery, except for Gjyshit beer, recycles their spent grains by distributing them to farmers for animal feed. Larger breweries, such as Birra Tirana, Birra Stela, Birra Kaon, and Birra Korça, sell their spent grains to farmers for profit—something the team had not observed when touring smaller U.S. breweries. Our interviews revealed that five of the seven Albanian breweries reuse their yeast for multiple generations, minimizing costs and reducing the amount of spent yeast. Spent grain is the only solid waste that is fully recycled, as all of the breweries mix their spent yeast, hops and trub with their wastewater and send it down the drain.

Declining domestic beer sales may discourage Albanian breweries from investing in new treatment processes to reduce their environmental impacts.

Through interviewing bar owners and brewers, the team learned that foreign beers are becoming increasingly popular in the Albanian beer market and many domestic are brands declining. Additionally, Albanians tend to favor products that are new to the market or perceived to have a higher quality. Some foreign beers, such as Birra Peja from Kosovo, have become increasingly cheaper to sell in Albania from a lack of import tariff enforcement at Albanian borders and possibly lower production costs in other countries. Declining sales may discourage Albanian breweries from investing in new treatment processes.

Figure E.3: The team touring Vlorë WWTP. Taken on Nov. 1, 2019.

The majority of consumers do not consider the environmental impact of the beer they purchase.

In our paper and online survey results (see Figure E.3), only 20% of consumers indicated that they considered the environmental impact in their decisions to buy a particular brand of beer before they purchased it. Of the rest of the respondents, 49% strongly indicated that they did not consider this an important factor. This illustrates that the greater number of our sample did not agree that the environmental impact was a reason they purchase beer, with the majority strongly indicating this attitude.

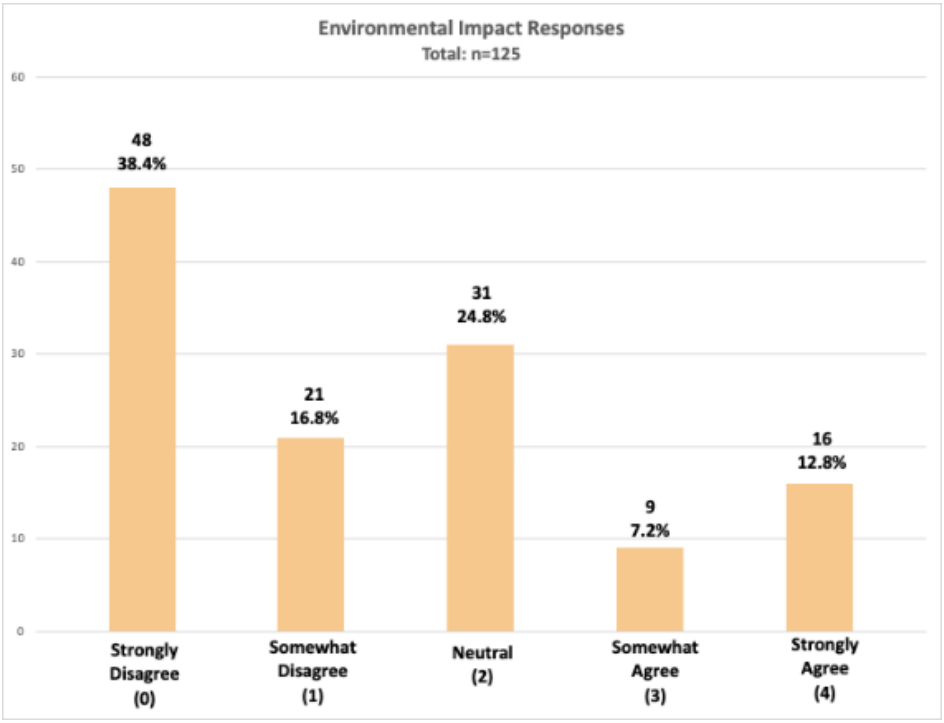

Figure E.4: Environmental Impact Responses

RECOMMENDATIONS

We recommend that SHUKALB develop a public education campaign to alert consumers of the environmental impacts of brewing beer Albania and influence consumer purchasing preferences to support more sustainable companies.

The team suggests SHUKALB assist breweries in implementing wastewater treatment systems and perform a cost benefit analysis for waste reuse processes. Wastewater is the largest waste stream in breweries and given that multiple Albanian breweries expressed interest in developing their own wastewater treatment systems, SHUKALB may be a valuable resource. A cost benefit analysis, while outside the scope of our project, would provide brewery's with to help determine if it is feasible and worthwhile for Albanian breweries to invest in treating their wastewater. It would provide brewers with valuable information on important economic factors, such as initial installation costs and possible return on investment. In addition to saving funds, the analysis should consider the potential environmental benefits of these new treatment processes and account for the intrinsic value associated with preserving natural resources.

Albanian brewers who are planning to expand or renovate, such as Birra Tirana and Birra Korça, should integrate environmentally friendly practices and equipment in their plans, with an emphasis on water reuse and reduction. These changes, while initially expensive, can reduce a brewery's operation costs.

Albanian breweries should also recycle their spent yeast, hops and trub as animal feed or fertilizer for local farmers. Currently, the breweries are washing all of these down the drain, causing their wastewater to have a high organic content. All of these waste products are suitable additives for animal feed and soil fertilizer. Reusing these wastes would decrease the organic matter that is discharged with the breweries' wastewater.

The team recommends that Albanian breweries begin advertising their sustainable practices. Although the consumer surveys indicated that the majority of our sample did not prioritize the environmental impact of a beer when purchasing it, 20% of respondents did consider it an important factor. With a growing beer market in Albania, this may be an easy strategy for Albanian breweries to engage consumers. Bars such as Illyrian Saloon and Duff Sports Bar indicated that the sustainable beer market has the potential to grow in the coming years. Thus, marketing adjustments could give breweries a competitive advantage in the market.

Figure E.5: The project team.

CONCLUSION

In conclusion, the team found that Albanian brewery practices are comparable to others around the world, the main difference being the availability of wastewater treatment. For example, in the United States, breweries send their wastewater to municipal facilities where it is fully treated, both physically and chemically. Breweries in Albania, except for Birra Korça, cannot connect to WWTPs. Albanian breweries have a higher environmental impact by default, as their wastewater enters the environment without treatment. Our research confirms that Albanian breweries are responsible for their own waste treatment, where initial costs and return on investment are the driving factors for them to both innovate and change. As Albania's industrial activity develops and water scarcity becomes a more prevalent issue in certain areas, industrial water reuse, reduction, and treatment will become an increasingly important endeavor. We hope that Albanian breweries will consider adopting practices that have a lower environmental impact in the future.

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Faleminderit shumë to…

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1.0 INTRODUCTION

The 2017 United Nations World Water Development Report estimates that over 80% of wastewater produced worldwide is discharged into the environment without treatment. On average, lower middle-income countries treat only 28% of the wastewater they generate. 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 the 181 countries in the world had full data sets in a recent analysis, but many are 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". It states that 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 central group 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 disruptions. 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 ten 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 (United Nations Economic Commission for Europe, 2018).

Beer breweries are a contributor to waste streams in Albania, but the extent of which is unknown. Breweries consume large quantities of water and produce sizable amounts of both 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). The Albanian brewing industry is growing, but how Albanian breweries are managing their waste is unclear. Brewery wastewater has a high organic load that is not suitable for direct discharge into the environment because it negatively impacts aquatic ecosystems. This can also impact downstream water resources that consumers and the public may interact with. 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). The team's project sponsor, SHUKALB (Water Supply and Sewerage Association of Albania) is interested in investigating current brewery practices and understanding how Albanian breweries could be encouraged to implement newer technologies to reduce the environmental impact of their processes and the waste they generate. Breweries stand to reduce operational costs, increase profits, and improve employee and consumer relationships with their brand by adopting more sustainable practices.

Our goal for this project was to evaluate Albanian brewery waste management practices and determine how breweries can improve their processes to reduce operational costs and their impact on the environment. We conducted a series of on-site tours and interviews at American and Albanian breweries, as well as Albanian wastewater treatment plants. Our project team consulted wastewater treatment professionals and surveyed Albanian beer consumers. Our research results include a set of high-level recommendations for future research objectives and for Albanian breweries. The information we obtained throughout the duration of the project lays 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.

2.0 BACKGROUND

Beer production in Albania began towards the end of the Ottoman Empire in the 1800s. Today, there are four large breweries and a handful of 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 is assessing the impacts of brewing beer as a part of these initiatives.

Section 1 of this chapter provides an overview of the history, economic impacts and cultural importance 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 possible 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. Finally, section 6 discusses the project's stakeholders.

2.1 GROWTH OF BEER PRODUCTION IN ALBANIA

HISTORY OF BEER IN ALBANIA

It is unclear when any type of beer production first began in the Albanian region. Prior to the establishment of the Ottoman Empire in the 1400s, communities and individuals produced and consumed wine 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 typically chose not to consume alcohol for religious reasons, 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 tax laws made it more economical to produce beer over raki or wine. These changes 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 a 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, located in Korçë, came to be known as Birra Korça. Birra Korça produced blonde ale, schwarzbier (black beer), pale ale, and malt. Following World War II (WWII), communism rose to power and the Albanian state nationalized Birra Korça (Birra Korça, 2017). There were no other commercialized breweries until 1960, when Birra Tirana became the second major brewery in Albania (Birra Korça, 2017).

In the 1990's, the beer brewing industry in Albania began to expand as the economy transitioned from socialism to capitalism. This new government structure created opportunities to open new companies, and soon other beer producers including Birra Stela and Birra Kaon entered the market.

TODAY'S ALBANIAN BREWERIES

Currently, there are four 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 micro and pub breweries, which are smaller in scale, are scattered throughout Albania.

Figure 1: Map of the main breweries in Albania.

Birra Korça is the oldest Albanian brewery and has a rich history that spans different owners and renovations. The projected production of the brewery was originally 20,000 hectoliters (hL) per year (1 hL=100 L) (Birra Korça 2017). Beer production in the Birra Korça brewery varied during the communist era. Production declined during WWII from 10,000 hL of beer per year to 600 hL of beer per year between 1939 and 1943. In 1957, though, Birra Korça made several renovations, and the brewery began to produce up to 46,300 hL of beer annually. In 1960, Birra Korça produced 52,000 hL, a record high. 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 hL 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 opened in 1960. Birra Tirana's initial production capacity was 75,000 hL per year. The brewery began by producing blonde and brass pilsner beer in 0.5-liter glass bottles as well as in 50-liter barrels. In 1983, Birra Tirana renovated its factory, increasing production to 150,000 hL per year, and replaced a majority of its production machinery with German and Swedish machinery (Birra Tirana 2019). Currently, Birra Tirana holds 30% of the beer market share in Albania. In 2001, the Albanian 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, and Switzerland (Birra Tirana, 2019).

Two newer, larger, commercial breweries rival Birra Tirana and Birra Korça. Stefani and Company, a shareholding organization, founded Birra Stela in 1991. Birra Stela's initial production capacity was 180,000 hL per year. Today, the company employs more than 130 people and produces over 250,000 hL per year. Birra Stela is the second most popular beer in Albania, accounting for 15-18% the Albanian beer 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 (Birra Kaon, 2017).

ECONOMIC INFLUENCE

The growing beer market holds an important niche in the Albanian culture and economy. While the average salary in Albania is about 444,000 Lek (4,020 USD) per year, Albanians distribute 12.8% of their income to restaurants (Numbeo 2019). In America, the average household income is 78,635 USD (about 8.80 million Lek), but Americans only spend 6.7% of their income at restaurants (Bureau of Labor Statistics 2019). This suggests eating at restaurants holds a high social importance and is a significant part of the Albanian economy. This information may be extrapolated to the beer market because beer is the third most consumed alcohol in Albania and Albanians frequently purchase beer with meals.

At a restaurant in Albania, 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. This price difference is advantageous to Albanian breweries and may contribute to their success in the beer market.

2.2 ENVIRONMENTAL IMPACT OF BREWERY WASTE

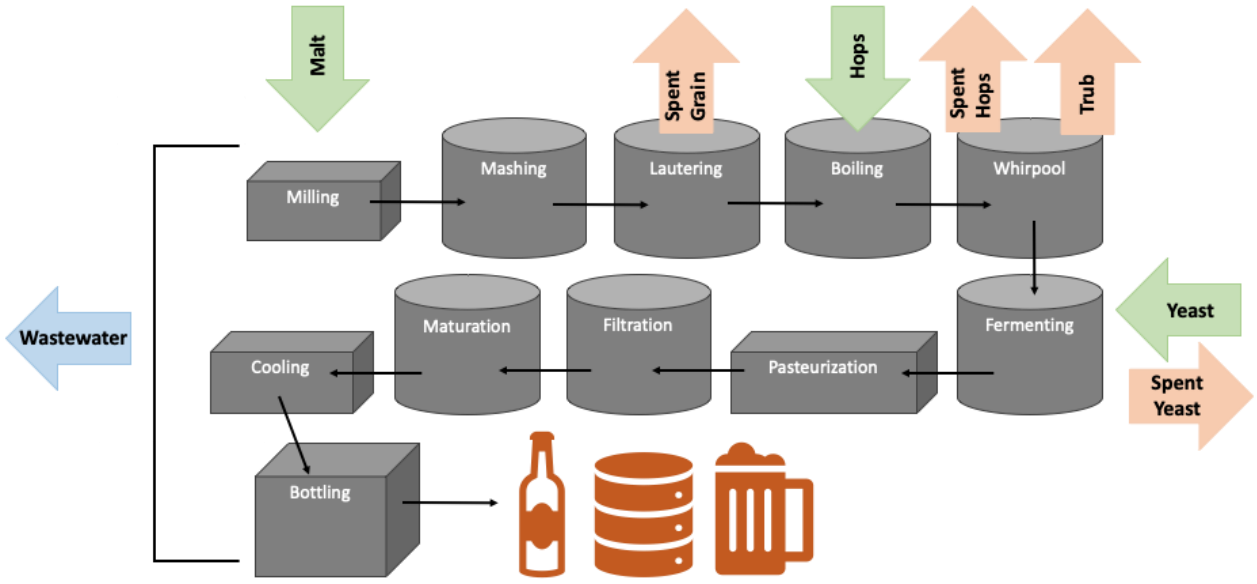

Figure 2: Beer brewing process flow diagram.

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 throughout the brewing process. Each of these wastes poses a different risk to the environment, which the team will explain in detail throughout this section.

THE BREWING PROCESS

The brewing process (see Figure 2) begins with barley, a major cereal grain produced worldwide. When brewers first receive barley, it is not particularly useful for 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." Brewers use a process called malting steeping to prepare barley for brewing. First, they moisten and aerate the grains 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). Breweries often purchase their grain in malt form.

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, to complete 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.

Next, the wort is boiled 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 to remove any remaining yeast and trub. Finally, it is filtered and pasteurized to remove any microorganisms before being packaged for consumption and sale (Willaert, 2007; S. Kmiotek, personal communication, September 05, 2019).

WASTEWATER

Brewers use water throughout the brewing process in stages such as mashing, boiling, and packaging, all of which generate wastewater. Wastewater contains cleaning detergents, chemicals, yeast, and organic matter (Amenorfenyo et al., 2019). The cleaning process produces the majority of brewery wastewater. The brewery must clean and rinse each bottle, keg, and tank involved in the brewing 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).

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 living in these ecosystems. These bacteria are responsible for the biodegradation of harmful aromatic hydrocarbons. An increase in these hydrocarbons causes the water body to emit an awful smell (Iheukumere et. al. 2014). A study, conducted by Devolli in 2018, tested Albanian wastewater and found increased acidity levels and high overall temperature in the affected ecosystems. Discharging untreated wastewater to sewer systems is not an environmentally viable solution. The mixture of beer brewery effluent and sewer water accelerates corrosion, producing 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. Hydrogen sulfide gas gives off a rotten egg smell.

SOLID WASTE

The brewing process also generates solid waste—which includes spent grain, yeast, spent hops, and trub. Grain filtered from the wort is considered spent and is no longer of use to brewers. On average, the process generates 20 kg of spent grain for every 100 liters of beer produced (Lynch et al., 2016). Bacteria and fungi rapidly colonize spent grain, causing it to spoil quickly. This presents a risk to the environment if breweries dump large quantities of spent grain into the environment and bacteria are left to grow in the waste.

High contents of nucleic acids are one of the main drawbacks of yeast waste. For monogastric animals, such as cows, sheep and humans, nucleic acids in extremely high concentrations make yeast less digestible, which can cause 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 (Caballero-Córdoba, 2011). Hops and trub waste pose a threat to the environment as well, because it contains 2-methyl-3-buten-2-ol, which is a product of the degradation of organic acids in the waste. This can cause hypnotic and sedative qualities if consumed in large concentrations, so hops and trub waste should not enter downstream consumption points (Farcas et al., 2017).

2.3 ALBANIAN INFRASTRCUTURE TO DISPOSE OF BREWERY WASTEWATER

HISTORY OF WASTEWATER INFRASTRUCTURE IN ALBANIA

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). The government developed water treatment and supply systems to match its directed population movements. After the fall of communism in 1990, the government no longer enforced population movement restrictions, 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 pace with changes in population. Regulatory organizations were not in place to monitor infrastructure. 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 increasing volume of Albania's wastewater (Rohde et al., 2004).

WASTEWATER LICENSING PROCEDURES

The Albanian government requires industries to have a license to operate; this includes a permit to operate a water system that involves wastewater and an environmental permit (see Figure 3). The Council of Ministers is the organization that assigns and distributes these licenses. Wastewater permits fall under at least one of four categories, labeled A through D (see Table 1). Breweries fall under category B (Personal Communication, Ministry of Tourism and Environment, Nov. 26, 2019).

Table 1: Categories of License Permits

Type	Category
A	Water Collection and Distribution for Public Consumption
B	Treatment of Water for Public Consumption
C	Disposal of Wastewater
D	Treatment of Wastewater

To obtain a wastewater permit, potential breweries must submit a number of documents to the Water Regulatory Authority (WRA) and turn in a file of legal resignation to the National Resignation Centre. This releases the brewery's information to the WRA and gives the WRA the legal right to distribute applicable permits. The WRA National Committee approves or denies all the documents the brewery submits. If approved, the WRA National Committee sends the final wastewater permit to the Council of Ministers (Water Regulatory Authority 2019).

A brewery must apply for an environmental permit with the Ministry of Tourism and Environment (MTE). This application process begins at the National Center of Business (NCB). The brewery must fill out paperwork to describe its operation, including how it plans to manage its waste, the projected capacity, emissions, and any resources the brewery will consume. The NCB then sends the environmental permit application to the National Environmental Agency (NEA) for approval. The NEA prepares a full permit draft and suggests operating conditions for the brewery (locations for waste treatment, the necessary capacity for waste treatment, and steps to take when there are no available treatment options). The NEA forwards the draft to the MTE, which finally approves it. The MTE publishes environmental permits online. Breweries pay an annual fee to renew their environmental permit. If approved, the Council of Ministers can review the permit, which, combined with the various other permits, allows them to administer the brewery's final operating license.

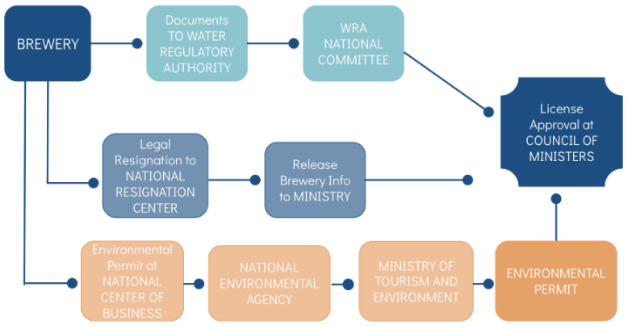

Figure 3: Diagram of license approval process.

CURRENT WASTEWATER TREATMENT PRACTICES

As of 2019, the Albanian government has constructed ten urban wastewater treatment plants with foreign donor support. These plants have the capability of treating approximately 25% of the country's urban wastewater, but no industrial wastewater. Albanian authorities have rendered three of these plants idle because of lack of financial and technical support (United Nations Economic Commission for Europe, 2018).

The government does not have financial support for water treatment and distribution. On average, 67% of drinking water in Albania is non-revenue, meaning the distributor does not profit from it. Current tariffs do not cover any of the 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). Water utilities bill approximately 30% of water production to consumers, and only 62% of those consumers pay their bills (Rohde et al., 2004). The majority of Albania relies on groundwater sources to supply drinking water which typically requires little to no treatment.

Both industries and urban areas discharge wastewater 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). Industries and urban areas dump solid wastes at unregulated sites due to insufficient access to landfills. Waste management regulations set by the Albanian government are difficult to enforce because there is not adequate water treatment, water distribution or 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 spent grain, and a "mixing and balancing tank" for wastewater before the brewery discharged the wastewater into the municipal sewer system (Devolli et al., 2018). The study found that farmers used spent grains and spent yeast 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 its 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 its 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. Table 2 at the end of this section provides an overview of each wastewater treatment option that breweries have.

Most treatment processes (see Figure 4) 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.

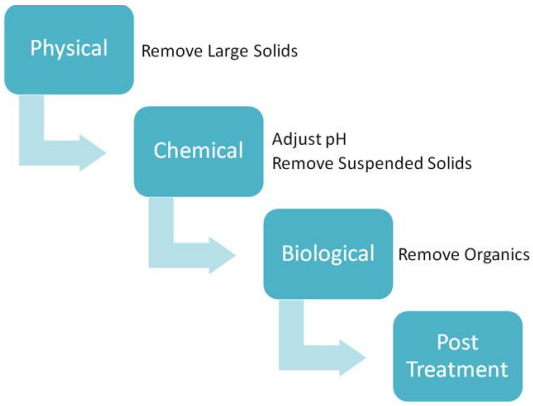

Figure 4: General wastewater treatment steps.

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 breweries discharge it to a surface water source. Simate et. al. (2011) cite that breweries can recover waste CO_2 from the brewing process to lower the pH of alkaline wastewater instead of using sulfuric or hydrochloric acids, which are both corrosive and costly. This reuses CO_2 that the factories would otherwise release to the atmosphere and reduces the amount of hazardous chemicals they use. Wastewater treatment plants generally treat wastewater color through coagulation and flocculation (see Figure 5). Coagulants are chemicals added to neutralize negative charges on dissolved particles. Treatment plants then add a flocculant to gather the particles and precipitate them out of solution, removing turbidity and color from water (Fosso-Kankeu et. al., 2018).

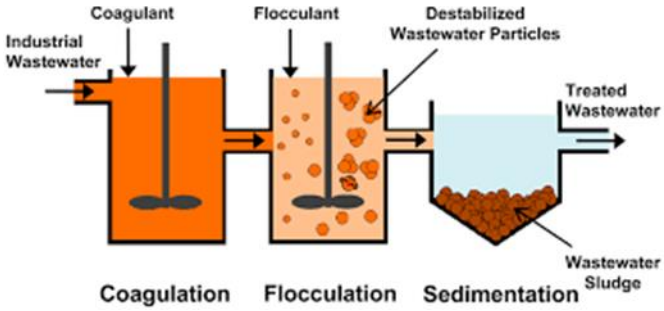

Figure 5: Flow diagram for a coagulation and flocculation process (Teh et al., 2016).

Biological treatment follows physical and chemical steps. Wastewater treatment plants and breweries around the world widely employ biological treatments because this technology effectively removes BOD (biological oxygen demand) and COD (chemical oxygen demand) from wastewater. 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 aerate in a tank to provide oxygen for the metabolization of the organic matter (see Figure 6). Sierra Nevada Brewery in Chico, California uses a two-step aerobic an anaerobic treatment process (Brewers Association, 2016).

Figure 6: Bluetongue Brewery's aerobic membrane bioreactor post-treatment stage. Water in this stage aerates 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 into biogas (methane and carbon dioxide) and sludge. Sludge is the solid organic matter that the microorganisms precipitate 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 upflow anaerobic sludge blankets (UASB) and fluidized bed reactors (FBR) (see Figure 7) (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. They then treat effluent water by membrane bioreactor, a type of aerobic treatment, and a reverse osmosis installation before it recycles back into the brewery (Brewers Association, 2016).

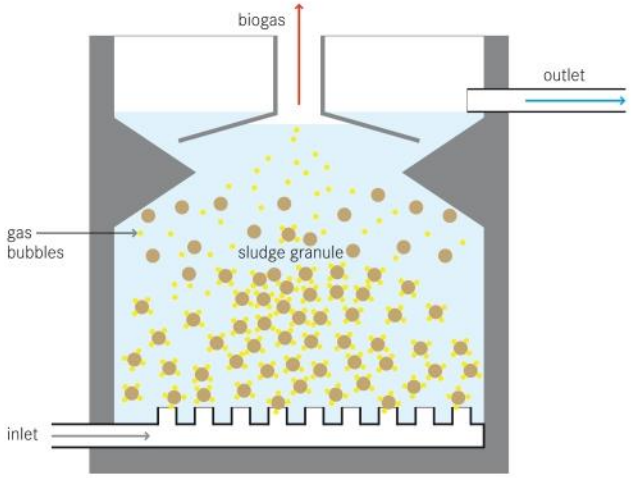

Figure 7: Schematic of a UASB reactor (Tilley et al., 2014).

Membrane filtration includes four subcategories based on the pore size of the membrane: microfiltration, ultrafiltration, nanofiltration, and hyperfiltration (Simate et. al., 2011). A 2004 study by researchers at the chemical engineering department of the University of Leuwen, Belgium (Braeken et al., 2004) demonstrates that nanofiltration removes 100% of COD in biologically treated wastewater and ~90% of COD in water used for rinsing in the brewing process. Membrane filtration equipment is subject to fouling, so it works best with minimal turbidity.

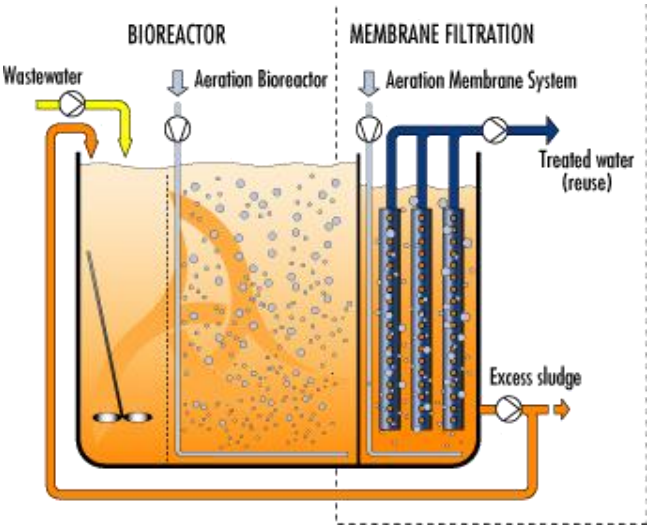

Figure 8: Diagram of a submerged MBR treatment system (Lenntech, n.d.).

Electrochemical methods work with varying wastewater strength. In a study published in 2006, researchers from the University of Putra Malaysia used hypochlorous acid (HOCl or weak bleach) generated from NaCl in an electrolytic reactor to remove COD from brewery wastewater (see Figure 9) (Vijayaraghavan et al., 2006). They added bisulfite 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 operators could treat the effluent stream with reverse osmosis to meet reuse standards within the brewery.

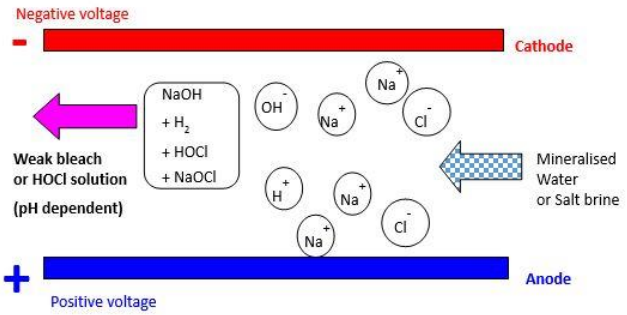

Figure 9: Production of HOCl from NaCl in an electrolytic reactor (ECA Consortium, 2017).

Microbial fuel cells (MFCs) produce energy by treating brewery wastewater. MFCs convert chemical energy from organic matter into electrical energy (see Figure 10). The process exposes an anode to the wastewater, and it then exposes a cathode to a chemical electron acceptor like oxygen. As bacteria oxidize organic matter, the anode captures electrons and transfers them 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. Researchers obtained power outputs between 11-12 W/m3 (Wang et. al., 2008).

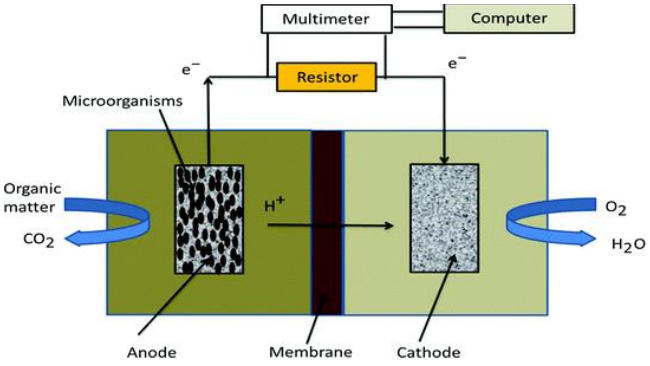

Figure 10: Microbial fuel cell diagram (Surajbhan et al., 2017).

Wineries widely employ constructed wetlands (CWs) to treat wine 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 breweries discharge it into the environment (see Figure 11). 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 breweries have not widely adopted CWs 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 Lanë River in Tirana from the 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).

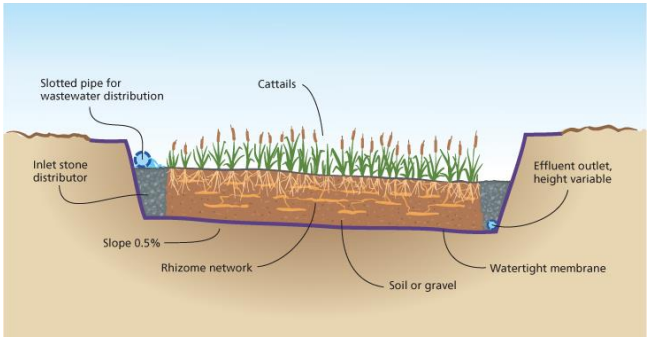

Figure 11: Constructed wetland diagram (Grismer, 2011).

After biological treatment, wastewater treatment industries remove odor and color from water with activated carbon. Chlorine molecules and molecules with carbon-sulfur bonds, which contribute to poor taste and smell, are easily adsorbed onto carbon (Simate et al., 2011). A variety of materials including coconut shells, peat, coal, petroleum pitch, and agricultural wastes make activated carbon (Hao at al., 2014). Brewing processes that produce clear beers also use activated carbon (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, effectively reducing the organic load of the effluent. An example of a microalgae treatment pond is shown in Figure 12. In a study by Luo et al. (2018) microalgae removed 78% of nitrogen and 92% of phosphorus from piggery wastewater. Travieso et al. (2008) showed that microalgae were capable of removing more than 98% of COD from a distillery's effluent. Microalgae treatments are less costly than traditional treatment methods and require a lower energy input. Algal biomass from the treatment has uses including fertilizer, animal feed, or biofuel (Amenorfenyo et al., 2019). Post treatment continues by removing the algal biomass which then produces high quality water.

Figure 12: An example of a microalgae treatment raceway pond. This configuration optimizes sunlight exposure (Breeden, 2017).

Table 2: Table of wastewater treatment methods, categorized by type of treatment.

Treatment Stage	Technology	Key Points
Physical	Filtration	Removes large solids
	Sedimentation	Removes large solids
	Membrane Filtration	Removes small solids
Chemical	Coagulation/Flocculation	Removes suspended solids
	pH adjustment	Neutralizes wastewater
	Electrolytic Reactor	Reduces COD
	Activated Carbon	Removes odor and color
Biological	Activated Sludge (aerobic)	Common in urban wastewater treatment Sludge can be used as fertilizer or to produce energy.
	Upflow Anaerobic Sludge Blankets (UASB)	Produces biogas which can be used to produce electricity.
	Fluidized Bed Reactors (FBR)	Produces biogas which can be used to produce electricity.
	Membrane Bioreactors (MBR)	Common in urban wastewater treatment.
	Microbial Fuel Cell (MFC)	Produces electricity.
	Constructed Wetland (CW)	Used frequently at wineries.
	Microalgae	Algal biomass can be used as fertilizer, animal feed, or biofuel.
Post Treatment	Chlorination	Used frequently in urban water treatment.
	Reverse Osmosis	Common for water filtration

WASTEWATER REUSE AND 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 limits the total amount of treatment needed. 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. 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. Brewers may combine these techniques with ones described in the Wastewater Treatment Section to then recycle their water.

Breweries should perform a water balance on each step in the brewing process to quantify overall water usage and identify potential reduction areas. Water flow meters can help identify water loss from leaks (Brewers Association, 2016). 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). This means that brewers can transfer wastewater streams containing detergents from different cleaning operations to reuse them as a strategy to cut down on water usage and cleaning chemicals.

Replacing traditional cleaning operations with Clean In Place (CIP) systems, (see Figures 13 and 14) 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 reuse wash solutions at various steps or recover them for future use (Pettigrew et al., 2015). CIP systems use caustic and acid solutions, which neutralize one another when mixed. Breweries can recycle these solutions until their pH no longer effectively sterilizes equipment, where they then mix the solutions to produce a pH neutral wastewater stream. 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).

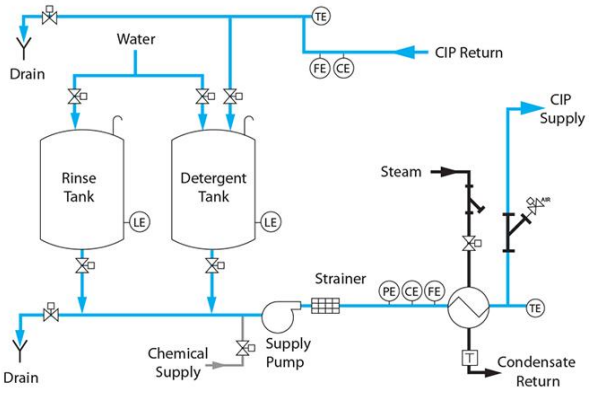

Figure 13: Schematic of a two tank CIP system. Cleaning solution cycles between brewery tanks and CIP rinse and detergent tanks (Sani-Matic, n.d.).

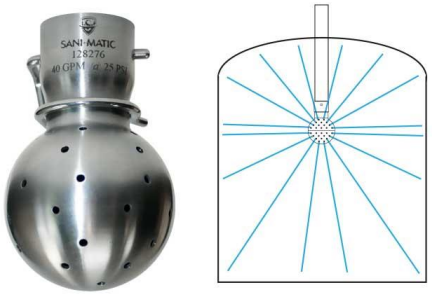

Figure 14: An example of a CIP system spray nozzle inside of brewing tanks (Sani-Matic, n.d.).

Closed loop heat exchanger used to cool brewery fermenters reuse water and reduce usage by more than 90% compared to single pass heat exchangers (Brewers Association, 2016). Packaging, cask, keg, and bottle washing, cooling towers, and steam boilers are other areas of the brewing process that have the potential to reduce water usage (S. Kmiotek, personal communication, September 05, 2019). Additionally, brewers can take weak wort from previous batches to be used in the next brew's mashing section. This reduces the amount of water consumed per brew and the COD levels of the brewery's effluent (Xhagolli et al., 2010).

SOLID WASTE REUSE

Spent grains, yeast, and hops generate a significant stream of solid waste in breweries. About 74-78% of protein in grain remains in the waste after the mashing process, so it is high in quality protein (Farcas et al., 2017). Farmers often use spent grains for animal feed but, with further processing, its uses expand to different industries.

The food industry can hydrolyze, or chemically break down, spent grains to produce emulsifying agents, flavor binders, valuable enzymes, and organic acids (Lexico, 2019). Other industries can use this hydrolyzed grain further by hydrothermally treating it for use as a carbon filter. Carbon filters remove contaminants or impurities through chemical adsorption with activated carbon (Hao et al., 2014). Additionally, the hydrolyzed grain can yield monosaccharide products such as xylitol, which is a sugar alternative. If the grain is in its natural state, the food industry can dry it and utilize it 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 industry uses range from medical to cosmetic (Farcas et al., 2017) (Mussatto et al., 2006). Given that wet grain highly encourages bacteria growth, drying spent grain prior to disposal is a method to reduce microorganism contamination (Farcas et al., 2017).

Brewers often collect spent yeast from fermentation and storage tanks and concentrate it to prevent a loss of product (Farcas et al., 2017). Yeast content contains over 40% protein, which makes it a valuable animal feed supplement when mixed with other feed (Brewers Association, 2016). Spent yeast is high in a variety of quality proteins, comparable to soy protein on today's market. The spent yeast contains a compound called monosodium glutamate, which has an "umami" flavor similar to the flavors of meat, making it valuable as a meat flavor substitute. Processing breaks the spent yeast down into β-glucans, which are sugars found in the cell walls of the yeast. Both the cosmetics and food industry have use for β-glucans, and the European Food Safety Authority approved it for use as a new food ingredient. The high salt content of the yeast limits its direct use in foods (Farcas et al., 2017) (Mussatto et al., 2006).

Finally, the brewing process produces spent hops and trub. Approximately 85% of the initial hops material ends up as a waste product. Farmers generally cannot use spent hops and trub directly as animal feed because they contain chemicals that, at high concentrations, can induce hypnotic and sedative properties if consumed. Due to these limitations, farmers can mix them with spent grain in smaller quantities. Another popular use is as a fertilizer or soil conditioner, as hops and trub contain high quantities of nitrogen. Newer uses include processing the waste through oxidation or hydrolysis, where chemical industries can use the products as a safe way to control bacteria in ethanol fermentation and organic acids (Farcas et al., 2017).

2.5 INCENTIVES FOR IMPROVED BREWRY WASTE MANAGEMENT

REDUCTION OF OPERATION COSTS

Reusing brewery wastes reduces operation costs and increases overall profits. The cost of using water in the brewing process includes more than just the price of tap water. The brewery water cost includes pretreatment, heating, cooling, and treatment again after use. These processes require energy and chemical inputs that greatly increase the total cost of using water. The quality of water also impacts 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, their 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).

Recycling spent grains and yeast from the brewing process is another method to reduce operational costs. Brewers can sell spent grains as fertilizers or animal feed supplements. In some areas of the U.S., breweries simply donate spent grains 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 reusing the yeast in the brewing process. (S. Kmiotek, personal communication, September 05, 2019). Artesian bakeries occasionally use spent grains 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

Specific groups of 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 mechanism 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 Indiana University, argues that through numerous tests and observations, consumers in the United States are "willing to pay a premium for sustainably brewed beer" (Sanya et al., 2018). While researchers have not conducted this study 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. This form of positive advertisement would encourage consumers to purchase their beer over other, non-sustainably brewed beers, giving brewers a competitive advantage in Albania's beer market.

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). Collaborative 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 participate 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 and advertisers for a company, and those who support their company's mission often communicate this support to customers through employee-customer interactions. These interactions 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 agencies that regulate wastewater, Albanian brewers, consumers of the beer, and the Albanian public that is exposed to the negative impacts of brewery waste. 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 organization 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. Consumers' interest and willingness to monetarily support a brewery funds these initiatives. 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.

Breweries send thousands of hectoliters of wastewater into bodies of water in Albania every year. They produce large quantities of solid brewery wastes that they often dispose of in unregulated sites. This presents a specific occurrence of pollution that researchers can study and quantify, 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.

3.0 APPROACH

The goal of this project was to assess brewery waste disposal practices in Albania and to recommend possible options for breweries to improve their waste management. Improving brewery waste management in Albania can reduce the impact breweries have on the environment and improve the quality of natural water sources. Breweries may also be able to reduce operating costs, increase profits, and increase employee and consumer engagement. The group's research objectives were as follows, and the flowchart below (see Figure 15) illustrates how we collected data to achieve these objectives:

- Assess wastewater systems near breweries to characterize the collection, treatment and disposal of brewery effluent.
- Assess how sustainable production processes can reduce operational costs for breweries.
- Evaluate current brewery waste management practices and their impact on the surrounding environment.
- Characterize beer consumer purchasing preferences to determine if consumers value a more sustainably brewed beer.

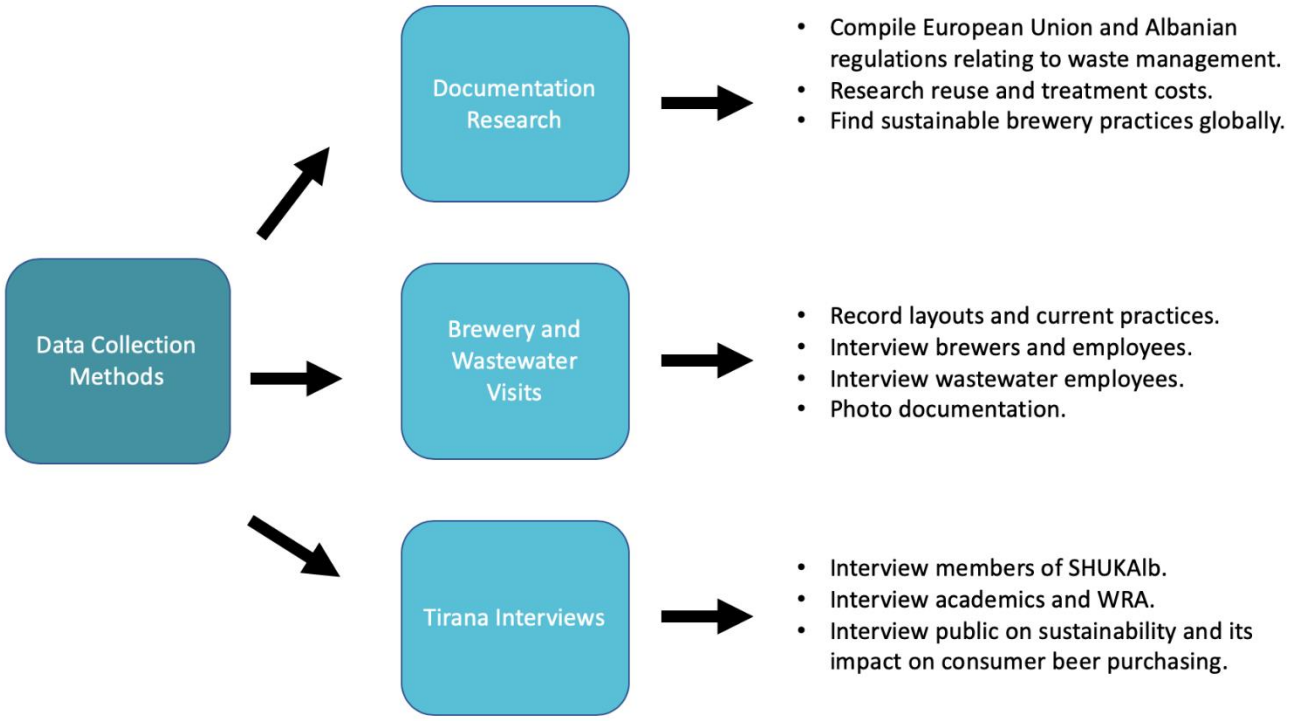

Figure 15: Data Collection Flowchart

3.1 ASSESS WASTEWATER SYSTEMS IN ALBANIA

The team examined current water supply and waste treatment infrastructure in Albania. Information was collected by interviewing wastewater and water supply experts, touring wastewater treatment plants, and reviewing Albania's regulations on industrial water use and treatment. Interviews addressed the challenges associated with regulating breweries and how regulators monitor waste disposal practices. Tours of wastewater treatment plants allowed us to assess what water treatment technologies are being used in Albania, how breweries connect to municipal systems, and if wastewater treatment plants are capable of treating brewery wastewater. The intent of this approach was to connect government regulation, municipal infrastructure, and brewery practices to provide a full picture of current brewery wastewater management practices in Albania.

This investigation used purposive sampling to select wastewater expert interviewees. The team selected interviewees from the Polytechnic University of Tirana, Albanian wastewater treatment plants, Albania's Ministry of Tourism and Environment, and the Albanian Water Regulatory Authority (WRA). This technique provided information from both academic and industry professionals and allowed the group to assess wastewater systems from different viewpoints. Table 3 below categorizes which individuals were interviewed from each organization.

Candidates were contacted through SHUKALB either by email or phone before the interview to confirm their participation. They were made fully aware that the information collected would be used for project purposes only and proprietary information would be kept confidential. The interviewee also had the option to remain confidential. Interviews followed the informed interview script outlined in Appendix A. Participants were given full access to the final report at the end of the project. These interviews addressed the following questions:

- What are the regulations for waste and/or wastewater disposal in Albania?
- How is water distributed and treated in Albania?
- What are the challenges in regulating an industry's wastewater practices?
- In what capacity do breweries connect to wastewater treatment plants?

Full interview questions for water sector organizations can be found in Appendix B, and Appendix C for WWTPs.

Table 3: Wastewater Professional Interviews

Agency	***Interviewee Title***	***Interview Date***
Polytechnic University of Tirana	- Environmental Engineering Faculty	Oct 22, 2019
Water Regulatory Authority	- Head of Technical and Licensing Directorate - Economic Directorate Member	Oct 29, 2019
WWTPs	- Vlorë WWTP Employees - Korça WWTP Head Chemist	Nov 1, 2019 Nov 15, 2019
AKUM	- Project director	Nov 22, 2019
Ministry of Tourism and Environment	- Director of Regulatory Directory	Nov 26, 2019

3.2 ASSESS HOW SUSTAINABLE PRODUCTION CAN REDUCE OPERATION COSTS

To determine what sustainable production processes can reduce operational costs in breweries, the team researched waste treatment, reduction, and reuse methods adopted by breweries around the world. Budget results, company websites, and academic articles were consulted to obtain information on the implementation, cost, benefits, and drawbacks of each option. The team also visited breweries and interviewed brewers in the New England area prior to travelling to Albania. This provided additional data on the costs, challenges, and benefits of implementing and maintaining waste treatment processes, and helped influence our interview questions for brewers in Albania. This research was entered into a table and organized by type of initiative (i.e. water use reduction, energy use reduction, water reuse) to compare the different processes. An example is shown below in Table 4.

This data provided an overview of the methods breweries worldwide have adopted to reduce their environmental

impact and how these changes have impacted their business. The following questions were answered through this research:

- What waste treatment, reduction, and reuse operations have breweries around the world implemented?
- What costs are associated with implementing these operations?
- What steps have breweries in New England taken to * reduce their environmental impact and how has that impacted their costs and profits?
- Which operations would be feasible for Albanian breweries to adopt?

The team compiled this information in a preliminary deliverable pamphlet to provide Albanian brewers with concrete information on how improving their waste management can increase their profitability and reduce their environmental impact. The pamphlet, shown in Appendices D and E, was given to brewers during or after their interview to encourage their participation in the project.

Table 4: 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				

3.3 EVALUATE BREWERY WASTE MANAGEMENT PRACTICES IN ALBANIA

The team toured breweries and interviewed brewers in Albania to assess current brewery waste management practices. The group determined specific actions breweries can take to improve their brewing process and reduce their environmental impact.

We selected breweries of various scales (pub brews, microbreweries, and large commercialized companies) through purposive sampling. Our goal was to visit at least three large breweries and at least five microbreweries/pub breweries to assess practices at each scale in the brewing industry. Large breweries and those outside of Tirana were contacted by SHUKALB to request an interview and tour.

The team visited smaller breweries in Tirana to request interviews and build a rapport with the owners. Each brewery was made fully aware that the collected information would be used for project purposes only and proprietary information would be kept confidential. The interviewee also had the option to remain confidential. All breweries were given full access to our final report and final deliverables at the end of the project. Interviews followed the informed interview script outlined in Appendix A, and the interview schedule and map of the breweries the team visited can be seen in Table 5 and Figure 16 below, respectively.

Table 5: Brewery Interviews and Tours

Brewery	Size	Location	Tour Date
Bräuhaus	Pub	Tirana	Nov 11, 2019
Birra Stela	Large	Tirana	Nov 12, 2019
Birra Korça	Large	Korçë	Nov 15, 2019
Birra Tirana	Large	Tirana	Nov 19, 2019
Birra Kaon	Large	Tirana	Nov 19, 2019
Birra Puka	Micro	Pukë	Nov 21, 2019
Birraria e Gjyshit	Micro	N/A*	Nov 25, 2019

**Currently do not have a location.*

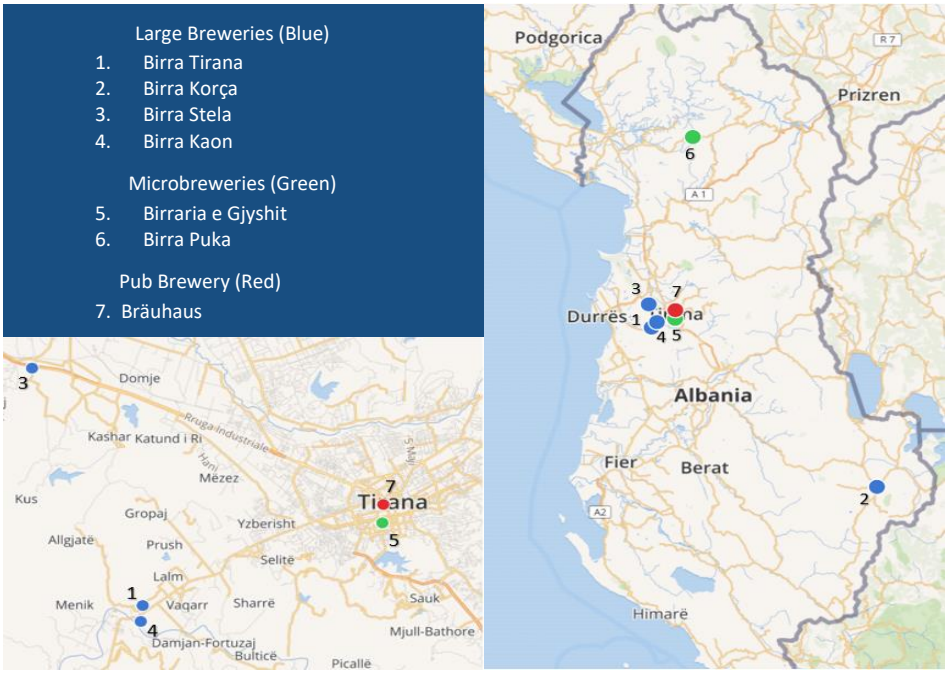

Figure 16: Map of breweries in the project.

During the brewery tours, the team also requested to photograph the brewery's processes. The team utilized the photographs to compare the processes of Albanian breweries to those we toured in the United States. The photos taken followed the photo script below, employing techniques outlined in Rose 2012.

- Where and how does waste leave the facility?
- What equipment does the brewery have in place for their cleaning and brewing process?
- How old is the brewery's equipment and what state is it in?
- Does the brewery have any established waste management infrastructure?

These photos are included in the findings chapter to demonstrate the types of equipment or processes the group mentions throughout the chapter.

Brewery interviews were semi structured and less formal than those the team conducted with wastewater professionals. In multiple cases, the brewer answered many of the interview questions through general conversation. During these visits, each team member was assigned a specific task (guiding the conversation, asking questions, note taking, photographing). These interviews addressed the following questions (see Appendix F for detailed questions):

- How and where are Albanian breweries disposing of their waste?
- How much wastewater and solid waste do Albanian breweries produce?
- What equipment was most expensive to implement and maintain?
- What are the largest challenges regarding brewery waste disposal?

By combining brewery tours, interviews, and photo documentation, the team was able to assess current Albanian brewery practices and find improvements to reduce the breweries' environmental impact.

Figure 17: The team interviewing a brewer.
Taken on Nov. 15, 2019.

3.4 CHARACTERIZE BEER CONSUMER PURCHASING PATTERNS

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 possible stakeholders, such as employees and investors (Section 2.5). Investigating how Albanian beer consumers perceive brewery waste management and sustainability initiatives was an important aspect of this objective. Breweries may be able to increase their profits by charging more for sustainably brewed beer; an increase in profits would provide more capital to purchase new equipment, train employees, or advertise sustainability initiatives. These breweries could 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 a more sustainability brewed beer.

This phase of our investigation used a Likert scale survey to determine what drives beer consumers to buy certain brands of beer over others. Likert scales are 5-point scales where individuals express how much they agree or disagree with a particular statement. This allows survey respondents to express their opinions in a quantitative form (McLeod, 2019). The survey asked participants to rate the importance of aspects such as price, packaging, and sustainability. The survey also included several questions to record the demographics of the survey group (age, gender, amount of beer consumed weekly). The team developed the surveys online using Qualtrics survey software and on paper. Online and paper surveys in English and Albanian are shown in Appendices G through J. For every question, survey takers were given the option to not answer. SHUKALB sent the online survey to their general mailing list. The mailing list includes other wastewater sector professionals, friends of employees, and other colleagues. The team anticipated there could be bias in the online surveys due to the assumption that individuals associated with the water sector would be more focused on environmental impact than those with no association.

The team visited four bars in Tirana to distribute the paper surveys to beer consumers. Surveys were distributed at locations based on convenience sampling, as the group was only able to distribute surveys to bars and restaurants that gave permission. Breaking up into teams of two, the group went table to table asking consumers if they would be willing to participate in the survey. The four bars (see Table 6 and Figure 17) include Duff Sports Bar, Radio Bar, Cheers, and Illyrian Saloon. At Duff Sports Bar the team was able to receive 19 completed surveys, 10 at Radio Bar, another 16 at Cheers, and finally 28 at Illyrian Saloon. We compiled responses from both the online and paper surveys in an Excel sheet and appropriate graphs were later constructed to interpret the responses. The group tabulated all survey data to compare and to determine beer consumer purchasing preferences. Tabulation of paper survey responses occurred in pairs. One person read the survey while another typed the results into the appropriate Excel columns. Questions with no response or multiple responses were rejected.

The team also interviewed owners of bars and restaurants that serve beer to gauge their attitudes towards serving more sustainably brewed beer. Interview questions can be found in Appendix K. Questions that the surveys and interviews addressed are as follows:

- Are Albanian beer 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?

Table 6: Bars and Restaurants Survey List

#	Restaurant/Bar	Location	Type of Restaurant/Bar	# of Surveys Completed	Distribution Date
1	Duff Sports Bar	Blloku	Bar	19	11/12/19
2	Radio Bar	Blloku	Bar	10	11/22/19
3	Cheers	Blloku	Bar	16	11/23/19
4	Illyrian Saloon	Blloku	Bar	28	12/2/19-12/6/19

Figure 18: Map of restaurants/bars included in the survey distribution.

3.5 DATA ANALYSIS AND OVERVIEW OF METHODS

An intern from SHUKALB accompanied the team on interviews and visits and served as a translator if the interviewee did not speak English. Most interviews were conducted in English, but some were conducted in Albanian. During these interviews, the intern led the conversation. They translated portions of the interview to be recorded by the note taker and helped add to the notes after the interview. The intern was given full access to the interview questions beforehand and was made aware of the information the group wanted to focus on. After each interview, the team compiled all of the gathered information as soon as possible into a shared document to ensure no data was lost or forgotten. Doing this also allowed us to familiarize ourselves with the data and record our first impressions.

To compare breweries in Albania to the United States, the team employed a deductive coding technique. The team developed coding categories based prevalent topics in our background research and interviews with U.S. brewers. A highlight color was assigned to each category, shown in Figure 18. After the interviews, two team members individually read through the group notes and highlighted sections that corresponded to each category.

Coding Highlight Colors

- Yeast Reuse
- Yeast Disposal
- Yeast Treatment
- Spent Grains Reuse
- Spent Grains Disposal
- Spent Grains Treatment
- Wastewater Recycling/Reuse
- Wastewater Disposal
- Wastewater Treatment
- Sustainable Infrastructure/Equipment

Figure 19: Interview Coding Colors

If the classification was relevant to more than one category, the phrase was highlighted half of one color and half of the other, as seen in Figure 19 below.

The yeast is used between three and four generations, and they send spent yeast into the sewer system when it's no longer viable.

Figure 20: Example of Interview Coding

The group chose a one-sample two-tailed t-test to statistically analyze the survey data. This type of test compares the mean of a single sample to an expected value when the standard deviation of the entire population is unknown. In the context of this project that means investigating whether any one factor is statistically different from the average ranking score. Since the sample for the survey data is not representative of the entire Albanian population, the population standard deviation was unknown, making this test appropriate.

After conducting a final analysis of all interview, tour, and survey data, the team developed a deliverable for SHUKALB using Piktochart software. This booklet highlights key points of research and contains a compilation of all of the findings throughout the project, including information on current brewery practices in Albania. SHUKALB intends on distributing this booklet to their mailing list and other interested parties. The team also sent the deliverable, along with the final project report, to the breweries, bars, and wastewater professionals who participated in the project.

4.0 FINDINGS

4.1 WASTEWATER REGULATIONS IN ALBANIA

Regulations are in place but are not strictly enforced.
Albanian breweries are subject to wastewater disposal regulations. Our interviews with Prof. Tonja Floqi, the WRA, AKUM, and the Ministry of Tourism and Environment helped the team understand the permitting system and how Albania enforces these regulations.

In addition to other paperwork, Albanian breweries must obtain an environmental permit prior to the construction and operation of their facilities. To obtain a permit, the brewery must complete an environmental impact evaluation and follow the steps outlined in Section 2.3 of the background chapter. The National Environmental Agency (NEA) drafts these permits, where it specifies how the brewery must treat, reuse, or dispose of its waste to remain under acceptable compliance. The permit also details the brewery's projected capacity, the source of its raw materials, and the brewery's plans to manage materials and equipment. Brewery environmental permits frequently list "no further treatment" for wastewater discharges. Breweries that put this down for a specific waste stream must coordinate with local authorities to identify disposal sites. "Composting at farms" is a typical response for spent grain waste (Personal Communication, Ministry of Tourism and Environment, Nov. 26, 2019).

The Ministry of Health and the Ministry of Tourism and Environment create regulations for wastewater treatment to closely follow regulations set by the European Union. The NEA enforces these regulations, but the agency only physically inspects municipal wastewater treatment plants in Albania on a regular basis, not breweries. The NEA expects individual industries such as breweries to self-monitor and report their status every six months. Each brewery must contract a government certified lab to test the water, air, and solid emissions from its processes. The brewery sends the results from these tests to the NEA to show they are in compliance with its original environmental permit. If the brewery is not in compliance with the permit, the Environmental Inspectorate monitors the brewery's operations on site. The Ministry of Tourism and Environment can issue fines to the brewery and possibly revoke its operating license if it does not comply (Personal Communication, Ministry of Tourism and Environment, Nov. 26, 2019).

The representative at AKUM stated that "...the law says wastewater should be treated, but does not necessarily say how," (Personal Communication, AKUM, Nov. 22, 2019). The regulating agencies do not provide industries with recommendations for treatment processes or assistance in designing treatment schemes, thus the term "treatment" is left for interpretation. Because the NEA does not directly monitor breweries on a regular basis, the regulatory system is based on trust in these industries to properly treat their wastewater before discharge from their facility. This practice is common in countries that often have limited funding or resources, as it allows the regulatory agencies to focus their attention to industries that may employ larger amounts of chemicals or discharge waste that poses a greater environmental risk than that of breweries (OECD 2007). The representative from AKUM commented that he "personally doubts that the law is fully implemented in breweries," (Personal Communication, AKUM, Nov. 22, 2019). According to one water service official, regulating industrial wastewater discharge is not the highest priority for the Albanian government—it is more focused on providing drinking water and treating urban wastewater. There are only so many personnel and resources available for the regulation of wastewater as a whole (Personal Communication, WRA, Oct. 29, 2019).

4.2 WASTEWATER TREATMENT INFRASTRUCTURE IN ALBANIA

Municipal wastewater treatment infrastructure does not handle brewery waste in most cases.

There are currently 10 WWTPs in Albania, some of which are not operating at full capacity. These facilities are located in Albania's largest cities, including Shkodër, Korçë, and Durrës. The Albanian government planned to build a treatment plant in Tirana, but the donor company, Japan Bank for International Cooperation (JBIC), backed out of the project and halted construction (Gjinali, 2010). Five of the seven Albanian breweries included in this project are located in Tirana where there is no wastewater treatment. In most cases, wastewater treatment infrastructure is not available for brewery use (Personal communication, AKUM, Nov. 22, 2019).

Even if the government receives funding for further implementation of infrastructure, WWTPs in Albania only treat urban wastewater; adding an entirely new framework for industrial wastewater treatment is not a priority. Wastewater treatment infrastructure is developing slowly in Albania due to a lack of funding and government planning and coordination. The Albanian government obtains funding for these facilities from outside donors and other European governments.

Albanian breweries cannot rely on municipal WWTPs to treat their wastewater.

The team toured two WWTPs in Albania to assess the current state of wastewater infrastructure in Albania. While there, the team also aimed to determine if the surrounding breweries connect to municipal sewer systems. Vlorë WWTP began operating in July 2017 and is the newest plant in Albania. The plant is in the developmental phase I of VII, meaning that only pretreatment steps are in place. The plant treats urban wastewater from the city of Vlorë using an activated sludge system to reduce the organic load of the effluent. This includes filters for large solids, a sedimentation section, FOG (fats, oils, and grease) removal section, and aeration and settling ponds. It does not coagulate or flocculate its wastewater. Vlorë WWTP is not operating at full capacity; currently the plant only produces 20% of the sludge required to treat the wastewater (Personal Communication, Vlorë WWTP, Nov. 1, 2019). Based on observation, it is clear that the wastewater treatment plant does not fully treat its water before discharging it t a neighboring canal, shown in Figures 20 and 21. The tea determined that this plant is not capable of treating brewery wastewater.

Figure 21: Discharge outlet at Vlorë WWTP. Taken on Nov. 1, 2019.

Figure 22: Discharge canal at Vlorë WWTP. Taken on Nov. 1, 2019.

Phase II of constructing the Sewerage Network in Vlorë began in February 2016 and ended in February 2018. Infrastructure only connects a portion of Vlorë to the WWTP. The team was unable to meet with Birra Norga, the large brewery located in Vlorë, so it is unclear how it treats their wastewater or if the sewer system connects it to the WWTP. The Vlorë WWTP employees could not share information on Birra Norga's wastewater management practices because they lacked permission from the plant's director to discuss the matter.

Korçë WWTP is the highest functioning plant in Albania. It treats urban wastewater from the city of Korçë but not industrial wastewater—Birra Korça is the only industrial wastewater contributor. The plant has the capacity to treat wastewater from 80,000 people; Korçë has a population of 55,000 people. Birra Korça contributes a wastewater volume equivalent to 5,000 people. The Korçë WWTP uses an activated sludge treatment system similar to that of the Vlorë WWTP. Filters remove large solids and a gravitational pump moves the wastewater into a series of aeration ponds (shown in Figure 22), then to a final polishing pond before discharge to a nearby canal. The plant's chemist stated that the facility follows current Albanian wastewater regulations for COD and BOD discharge limits (Personal Communication, Korçë WWTP, Nov. 15, 2019).

Based on information given by SHUKALB, Korçë WWTP is an example of the best wastewater treatment in Albania, but most facilities, according to regulatory officials, fall closer to Vlorë. The remaining WWTPs in Albania are unlikely to have the capacity or technology to treat brewery wastewater in addition to urban wastewater. Additionally, wastewater conveyance systems are underdeveloped—only 52% of Albania is covered by sewer systems (Personal Communication, WRA, Oct. 29, 2019). This may change in the future as the government constructs more wastewater treatment infrastructure, but for now Albanian breweries cannot rely on municipal systems to treat their wastewater. With the lack of industrial wastewater treatment infrastructure in Albania, the team concluded that breweries are responsible for developing their own wastewater treatment alternatives to protect the natural resources around them.

Figure 23: An aeration pond at Korçë WWTP. Taken on Nov. 15, 2019.

4.3 BREWERY WASTEWATER

Wastewater from Albanian breweries is generally not treated before discharge.

Every Albanian brewery interviewed sends their wastewater to municipal sewer systems, which often discharge directly into the environment. Birra Korça is the only brewery that is connected to a WWTP. Four of the seven breweries, Bräuhaus, Birra Kaon, Birra Puka, and Birra Gjyushit, do nothing to pretreat their wastewater before discharge. All seven of the breweries combine wastewater produced from cleaning with the wastewater streams the brewing process produces.

All of the breweries clean their equipment with caustic and acid. Six of the seven breweries reuse their cleaning chemicals until they are no longer effective (they determine this by testing the pH). An example storage container for their cleaning solutions can be seen in Figure 23. Birra Puka utilizes cleaning chemicals only once before combining them with its wastewater stream.

Three of the seven breweries visited in Albania, Birra Tirana, Birra Stela, and Birra Korça, neutralize their wastewater before discharge. Wastewater with a high or low pH puts stress on the ecosystem, as strong acids and bases affect water, plants, and soil. All three breweries have large tanks that collect all wastewater from their brewing and cleaning processes. An example of these tanks is shown in Figure 24. Residual caustic and acid cleaning solutions neutralize each other in these tanks. A technician then adds additional acids or bases to neutralize the pH of the mixture if needed.

Birra Tirana and Birra Stela send the wastewater down the drain which leads to the Lanë River. Birra Korça discharges its wastewater into the Korçë sewer system which leads to the Korça WWTP for further treatment. The remaining four breweries do not mix or neutralize their wastewater before discharge. None of the breweries pretreat their wastewater to reduce its BOD or COD content. Wastewater with high BOD and COD content causes dissolved oxygen levels to decrease, making the water not suitable for aquatic life.

Figure 24: Cleaning chemical storage vessel at Bräuhaus. Taken on Nov. 11, 2019.

Figure 25: Wastewater neutralization tanks at Birra Tirana. Taken on Nov. 19, 2019.

In all breweries, cleaning procedures generate the most wastewater.

The cleaning process produces the greatest amount of wastewater for every brewery the team has visited in Albania and the United States. In each brewery, cleaning procedures consume at least the same volume of wastewater required to brew each batch of beer. During peak brewing seasons, breweries produce a higher volume of wastewater, but generally have lower beer volume to wastewater volume ratios. Breweries clean their tanks before and after each batch when they do not brew consecutive batches. Larger breweries, such as Birra Tirana, brew at higher capacity during peak season and only clean its vessels once in between each brew as opposed to the regular pre and post brew clean.

Water accounts for a high percentage of operating costs.

In many Albanian breweries, the cost of water is the most expensive part of producing beer. Albanian breweries pay for both their water supply and wastewater disposal. Water for brewing beer in Albania comes from either wells or water utilities.

Birra Stela and Birra Korça both have private wells that provide water for their facilities. Both breweries previously operated with the city's water utility line but began drilling wells to reduce water costs. Even though the breweries own the wells, the Albanian government taxes the water drawn from them.

The companies may own the land, but the government owns any underground resources, meriting the well taxation. Furthermore, the expenses involved with digging and well upkeep are the responsibility of the breweries. Well water frequently has a high salt content, so both Birra Stela and Birra Korça filter their water with reverse osmosis and carbon filters before using it in their brewing process.

Birra Tirana, Birra Kaon, Birra Puka, and Bräuhaus draw their water from their respective city water lines. All of these breweries claim the most expensive part of their brewing process is water. Birra Tirana and Birra Kaon utilize reverse osmosis filters and Bräuhaus treats its water with carbon and quartz filters. Birra Puka does not pretreat its water. Regardless of where the water comes from, breweries must pay to dispose of the wastewater through the sewer. This cost is frequently included in the brewery's water consumption bill, which factors in the water source, usage amount, and method of disposal. Birra Korça claims 65% of its production costs are for the use and disposal of water.

Figure 26: CIP system at Birra Tirana. Taken on Nov. 19, 2019.

Albanian breweries have implemented water saving processes.

The majority of the Albanian breweries interviewed for this project have implemented water saving equipment and processes. Five of the seven Albanian breweries have CIP systems in place to clean their equipment (see Figure 25). This technology reuses caustic and acid cleaning chemicals and reduces the amount of water needed in the cleaning process (See Section 2.4 of background). Every brewery uses low water consumption spray nozzles to clean their tanks (see Figure 26). These nozzles increase water pressure and spray the cleaning solution in all directions to reduce the number of rinses necessary to clean the tank (See section 2.4 of background).

All breweries use a closed loop heat exchanger to cool the wort as it is sent to the fermentation step (see Figure 27). Every brewery, except Birra Puka and Gjyshit beer, sends hot water from the heat exchanger to the mashing section to begin the next batch of beer. Birra Puka implemented a glycol heat exchanger, which cycles glycol and does not require water. Lastly, three of Albania's largest breweries, Birra Korça, Birra Stela, and Birra Tirana, recycle water within the pasteurization section. Both closed loop heat exchangers (see Figure 27) and water saving pasteurization sections reduce the amount of energy the brewing process needs to heat water, in addition to decreasing water usage.

Table 7 at the end of this section summarizes and compares current water reuse, recycling, and treatment methods in place at the Albanian breweries included in this project. The N/A symbol indicates that the brewery in question does not have a pasteurization process in place.

Figure 27: Low water consumption spray nozzle at Birra Puka. Taken on Nov. 21, 2019.

Figure 28: Closed loop heat exchanger at Birra Puka. Taken on Nov. 21, 2019.

Table 7: Water Reuse, Recycle, and Treatment Methods Implemented in Albanian Breweries

Brewery	CIP System	Spray Nozzles	Closed Loop Heat Exchanger	Pasteurization Tunnel	Wastewater Neutralization
Bräuhaus	X	X	X	N/A	
Birra Korça	X	X	X	X	X
Birra Stela	X	X	X	X	X
Birra Tirana	X	X	X	X	X
Birra Kaon	X	X	X		
Birra Puka		X		N/A	
Birraria e Gjyshit		X		N/A	

4.4 BREWERY SOLID WASTE

Albanian breweries partner with farmers to reuse spent grains

Albanian breweries are already taking steps to reduce their environmental impact by reusing spent grain. All but one Albanian brewery the team interviewed reuses spent grain by distributing it to farmers as animal feed filler. Breweries do not treat or dry their grains before distributing them; in most cases, the mixing of the lautering tun drains the grains of excess wort before moving the grain to external containers.

Larger breweries, such as Birra Stela, Birra Tirana, Birra Kaon, and Birra Korça charge farmers for the spent grain and make a profit. These breweries store their spent grain in grain silos in between batches because they produce such a large volume, shown in Figures 28 and 29. Smaller breweries, such as Bräuhaus and Birra Puka give their spent grain away for free using grain sacks or bins, shown in Figure 30. In all cases, the farmers pick up the spent grain from the brewery. Gjyshit beer is the only brewery the team met with that does not reuse its spent grain. Currently, Gjyshit beer does not have a brewery location and is currently looking for a new one to expand its operation. It plans on separating out its spent grains to give to farmers for future processes once it finds a new facility in the coming months.

Figures 29 and 30: The spent grain silo at Birra Tirana. The left figure shows the chute used to dispense the grain into farmers' trucks. Taken on Nov. 19, 2019.

Figure 31: Bin used to transport spent grains at Bräuhaus. Taken on Nov. 11, 2019.

Some Albanian breweries reuse yeast to cut down on operational costs.

Reusing yeast cuts down on operational costs and reduces the organic load of brewery wastewater, the organic load that can increase the BOD and COD of the water. On average, yeast cells can be reused around 3-4 generations, depending on their life span. Every brewery that we met, except Gjyshit beer and Birra Puka, reuse their yeast for multiple generations. Birra Tirana, Birra Stela, and Birra Kaon all reuse their yeast for around 6-7 generations, while Birra Korça reuses its yeast around 2-4 generations. Smaller breweries, both in the U.S. and Albania, are hesitant to reuse yeast because they do not have the proper equipment, space, or specialized knowledge. Smaller craft breweries, such as Gjyshit beer, that produce many types of beer are frequently unable to reuse yeast because each variety of beer requires a different yeast strain. The yeast also takes on the characteristics (flavor and smell) of the beer it is used in, so brewers cannot reuse it between different types of beer (Personal Communication, Rapscallion Brewery, Oct. 11, 2019).

Albanian breweries do not reuse spent yeast, trub, and hops.

Albanian breweries dispose of spent yeast, trub, and hops by sending it down drains with their wastewater. Brewers either strain or filter the mix of live and dead yeast cells out of the beer, depending on the process. If the cells are no longer viable, the breweries dump the spent yeast down the drain and mix it with other wastewater streams (see Figure 31). Some breweries, including Bräuhaus and Gjyshit beer, do not fully remove yeast from their beer. This practice is seen in craft breweries as it can further enhance flavor. In all breweries, though, dead yeast cells settle to the bottom of fermentation tanks along with other suspended solids. All Albanian breweries remove these solids and send them down the drain, which leads into the environment.

Figure 32: Spent yeast from a fermentation tank being washed down the drain at Birra Stela. Taken on Nov. 12, 2019.

Figure 33: Brewer adding hop pellets to the wort at Birra Puka. Taken on Nov. 21, 2019.

Albanian breweries have implemented other reuse and reduction methods to further reduce costs.

The team did not anticipate some of the reuse procedures in place at the Albanian breweries because they were not present at the small U.S. breweries we toured. These procedures include both carbon dioxide recapture and the recycling of bottles and kegs.

Both Birra Korça and Birra Tirana have carbon dioxide (CO_2) recapture systems (see Figure 33). This means that a series of machines collect the CO_2 yeast produce during the fermentation stage, to then condense, liquefy, and store it. The breweries reuse this CO_2 later on in the brewing process to adjust the levels of carbon dioxide in matured beer for quality and standardization purposes. This practice reduces production costs because the breweries do not need to purchase additional CO_2. It also eliminates the discharge of CO_2 into the atmosphere, reducing the brewery's carbon footprint.

Figure 34: CO_2 reuse system at Birra Tirana. Taken on Nov. 19, 2019

The majority of the breweries visited have some form of package recycling system. Birra Korça, Birra Tirana, and Birra Kaon reuse both their kegs and their glass bottles; examples of these can be seen in Figures 34 & 35. The breweries generally only buy new bottles to replace broken bottles that distributors return. Birra Korça estimates that it receives 90% of its bottles back via its distributors, and that each bottle has a lifetime of about five uses. This keeps bottles out of landfills, reduces the energy required for bottle production, and reduces the number of bottles breweries need to purchase.

All breweries clean and reuse their kegs. Bräuhaus and Birra Puka only sell their beer in kegs because they are such small breweries. Bräuhaus uses kegs only during the summer when it sells its beer outside of the restaurant, and for parties that purchase kegs for catering. During the rest of the year, Bräuhaus stores its beer in stationary holding tanks which connect to the restaurant's bar tap.

Figure 35: Recycled kegs at Birra Korça. Taken on Nov. 15, 2019

Birra Stela uses plastic bottles, glass bottles, cans, and kegs, but it recycles its packages in an unexpected way. A third-party company collects and recycles the used bottles and cans from the brewery. The company converts the plastic bottles to plastic cling wrap. The brewery uses this wrap as final packaging for Birra Stela's products before distribution. These reuse processes were not the team's original focus, but through the interviews we came to find that these procedures saved materials and reduced the overall waste from the breweries. Table 8 at the end of this section comparatively outlines what each Albanian brewery does with its various solid wastes.

Figure 36: Crates of glass bottles distributors return to Birra Tirana after use. Taken on Nov. 19, 2019.

4.5 ALBANIAN BREWERY WASTE MANAGEMENT IN COMPARISON TO BREWERIES AROUND THE WORLD

Albanian breweries use many of the same processes as breweries around the world.

From our previous research, we identified several breweries around the world that prioritize sustainability in their brewing processes. These breweries share some of the same processes as those in Albania. For example, Beau's All-Natural Brewing Company (Vankleek Hill, Canada) and Sierra Nevada Brewing Co. (Chico, CA) reduce their CO_2 emissions by reusing the CO_2 emitted by their fermentation section. Birra Korça and Birra Tirana had the same process in place in their breweries.

All over the globe, industries utilize CIP cleaning systems as an efficient technique to reduce water consumption and save chemicals during the cleaning process. Birra Kaon, Birra Tirana, Birra Korça, Birra Stela, and Bräuhaus have all implemented CIP systems. Other breweries such as Big Mountain Brewing Company (Passy, France) and Purity Brewing Company (Alcester, United Kingdom) reuse hot water from their heat exchangers for their mashing stage. Similarly, all of the breweries we met with in Albania have closed loop heat exchangers as well. In addition, almost all Albanian breweries have a system in place with their distributors to collect and return their glass bottles and kegs for reuse. From our research on breweries around the world, we were only able to find this practice advertised from Big Mountain Brewing Company.

While the group had anticipated otherwise, Albanian breweries were quite similar to other breweries we researched around the world. While they are not as committed to sustainability as many other breweries, Albanian breweries still have several systems in place that enable them to successfully reuse and reduce consumption of certain materials.

Albanian brewery processes and waste management practices are comparable to U.S. brewery practices.

Albanian brewing processes are comparable to the U.S. practices regarding waste management. All four U.S. breweries the team visited reuse hot water from their heat exchangers. Six of the seven Albanian breweries also do this. Every brewery the team interviewed in both the U.S. and Albania, except Birra Gjyushit, distributes its spent grains to local farmers. Larger breweries including Birra Stela, Birra Kaon, Birra Korça, and Birra Tirana, profit from their spent grains, a practice we did not observe in the U.S. breweries.

Reusing yeast is another common practice in the U.S. and Albania. Three of the four breweries we met with in the United States, Greater Good Imperials, Rapscallion Brewery, and Redemption Rock Brewing Co., reuse their yeast. Five out of the seven breweries we toured in Albania also reuse their yeast. The number of generations the brewery reuses the yeast for varies anywhere from two to seven generations.

CIP systems are common in the United States and are in place in the majority of the breweries the team toured in Albania. All of the breweries in the U.S. have CIP systems in their tanks. Five out of seven Albanian breweries use CIP systems in their tanks, including Birra Tirana, Birra Kaon, Birra Stela, Birra Korça, and Bräuhaus. All Albanian and U.S. breweries clean their tanks with low water consumption spray nozzles. Breweries in both the U.S. and Albania discharge their wastewater to the sewer system. The only difference between the two disposal practices is that WWTPs are in place in the U.S. but not available in Albania.

4.6 ALBANIAN BEER CONSUMER PURCHASING PREFERENCES

Foreign beers are gaining popularity in the Albanian market.

In the current Albanian beer market, restaurants, bars, and stores sell some foreign beers at a lower price than Albanian brewed beer. Foreign beer has become increasingly cheaper to sell in Albania because of the lack of border enforced tariffs on imported beer. Foreign breweries with lower production costs sell their beer at a further reduced price than breweries in Albania. An example is Birra Peja from Kosovo.

Additionally, Albanians tend to favor products that are "new and exciting" (Personal Communication, Birra Stela, Nov. 12, 2019). Albanian beer consumers seek to try new beers from other regions in Europe such as Belgium and Germany. They believe these beers are of higher quality than Albanian beers. Multiple bars and restaurants we have interviewed, such as Duff Sports Bar and Illyrian Saloon, sell few to no commercial Albanian beers because of their low popularity.

Declining sales may discourage breweries from investing in new treatment processes.

Due to the increase in popularity of foreign beers, many Albanian breweries are experiencing a decline in their sales. Bräuhaus, Birra Stela, and Birra Kaon have all experienced different levels of declining sales, while Birra Korça is the only brewery that is still steadily increasing. Birra Tirana and Birra Puka both experience ups and downs, but their recent sales numbers have generally remained steady. This decline or stagnation in sales suggests brewers are less likely to invest in on-site treatment processes because they may not be able to profit from these renovations right away.

The majority of beer consumers tend to drink the same beer as their friends and family.

Another aspect of this investigation was to distribute beer consumer surveys in both an online and paper format. SHUKALB emailed our online survey to its personal mailing list. The mailing list includes other wastewater sector professionals, friends of employees, and other colleagues. The team anticipated there would be a bias in the online surveys due to the assumption that individuals associated with the water sector would be more focused on environmental impact than those with no association. The group distributed paper surveys to customers of Illyrian Saloon, Cheers, Radio Bar, and Duff Sports Bar.

For all of the surveys, the team asked participants to rank the degree to which they agreed with various statements. Zero indicates strongly disagree, two indicates neutral and four indicates strongly agree. For both Figures 36 and 37, the average response value is along the x-axis, and each statement the survey asked participants is in a shortened version on the y-axis (see Appendix G for the precise survey choices). An example of the Likert scale responses is along the x-axis of Figure 38. Varying results from online and paper formats of the beer consumer surveys are shown below in Figure 36, with the combined results shown in Figure 37.

Both graphs indicate the most influential factor in a beer purchase is what beer the consumer's friends and family are drinking. Using the one-sample two-tailed t-test outlined in Section 3.5 of the approach chapter, the team can conclude that this factor was significantly higher than the rest of the factors. Furthermore, when the average of the friends and family factor was compared with the overall average rank score, the value was 71% larger than everything else. The manager of Cheers bar remarked that people in Albania often have strong brand loyalties to popular beer, which indicates that consumers follow social norms. This is a potential threat to domestically brewed beer, as the excitement over foreign beer and its continued prevalence is something that can highly influence the market as a whole.

The majority of consumers do not consider the environmental impact of the beer they purchase.

From our paper and online survey results (see Figure 37 below), the average answer for whether the environmental impact of a beer factored into the purchase was 1.3 out of 4. This was the second to lowest factor. Of all of the responses (see Figure 38), only 20% of consumers indicated that they considered the environmental impact of a beer before they purchased it. Of the rest of the respondents, 49% strongly indicated that they did not consider this an important factor. This shows that from our sample, while a percentage do consider the environmental impact of a beer, the vast majority do not prioritize it. The response results were similar in both the paper and online survey format.

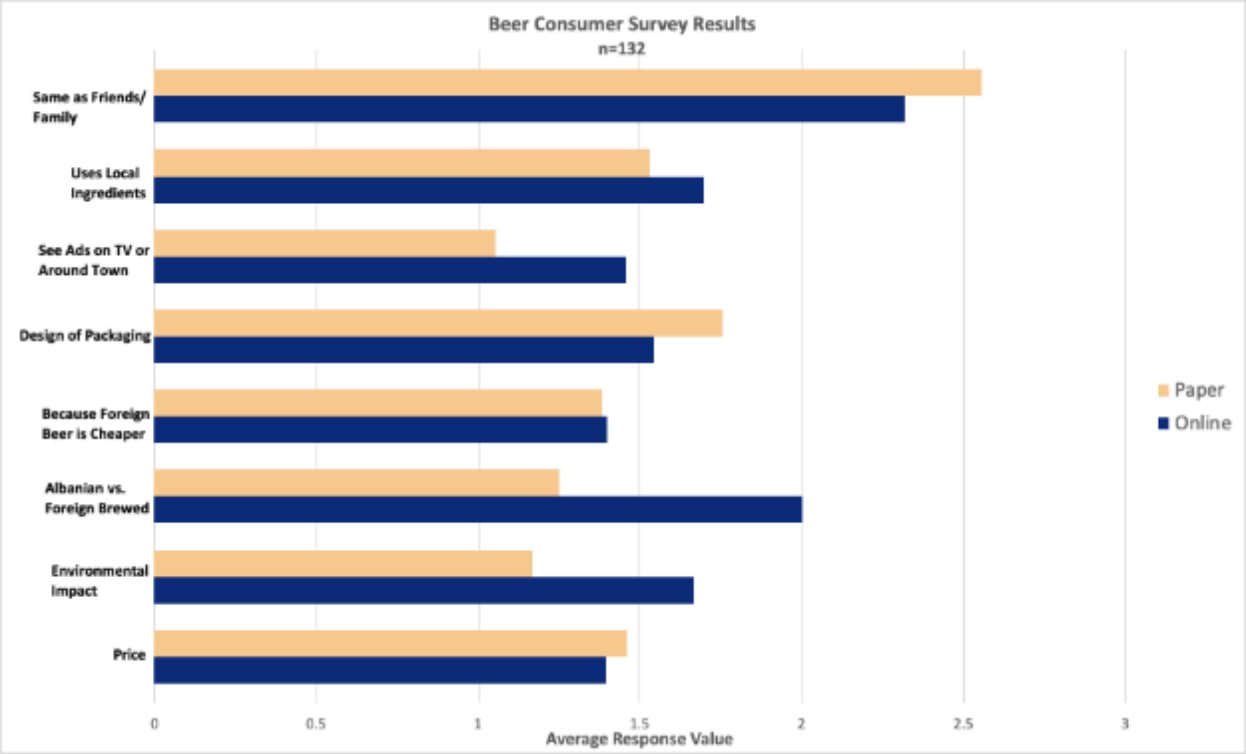

Figure 37: Beer Consumer Survey Results

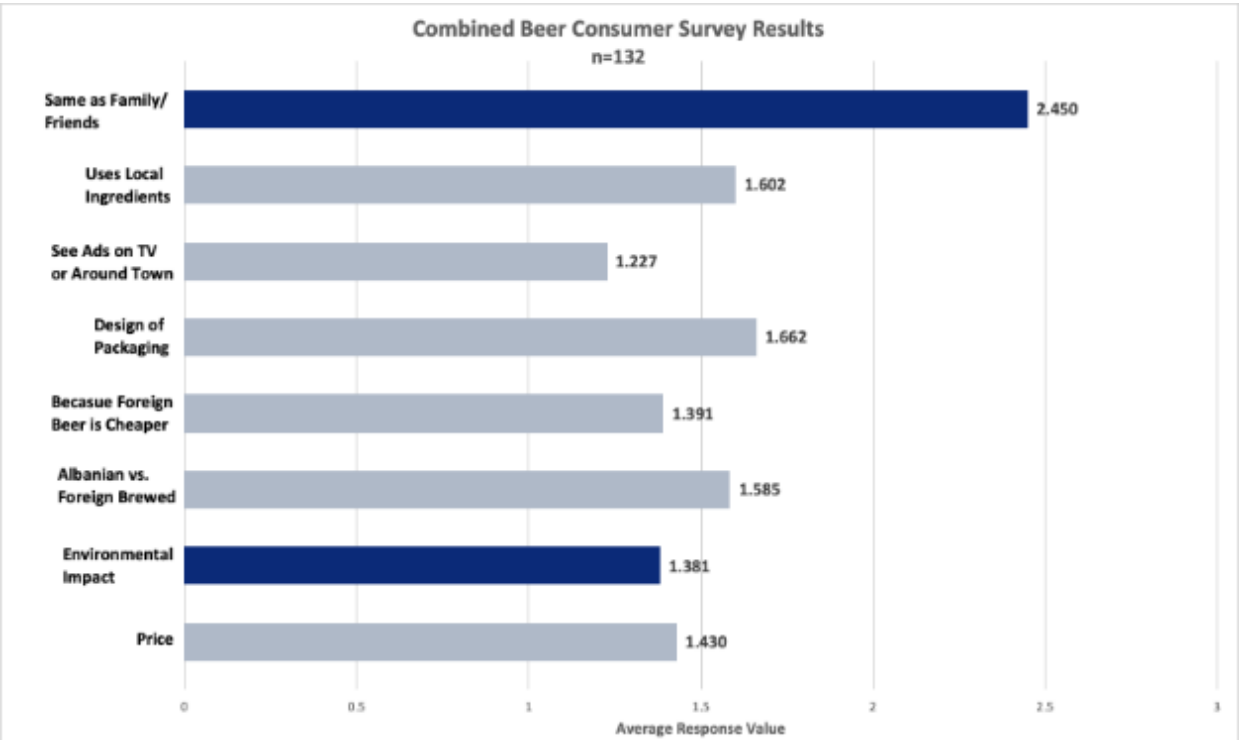

Figure 38: Combined Beer Consumer Survey Results

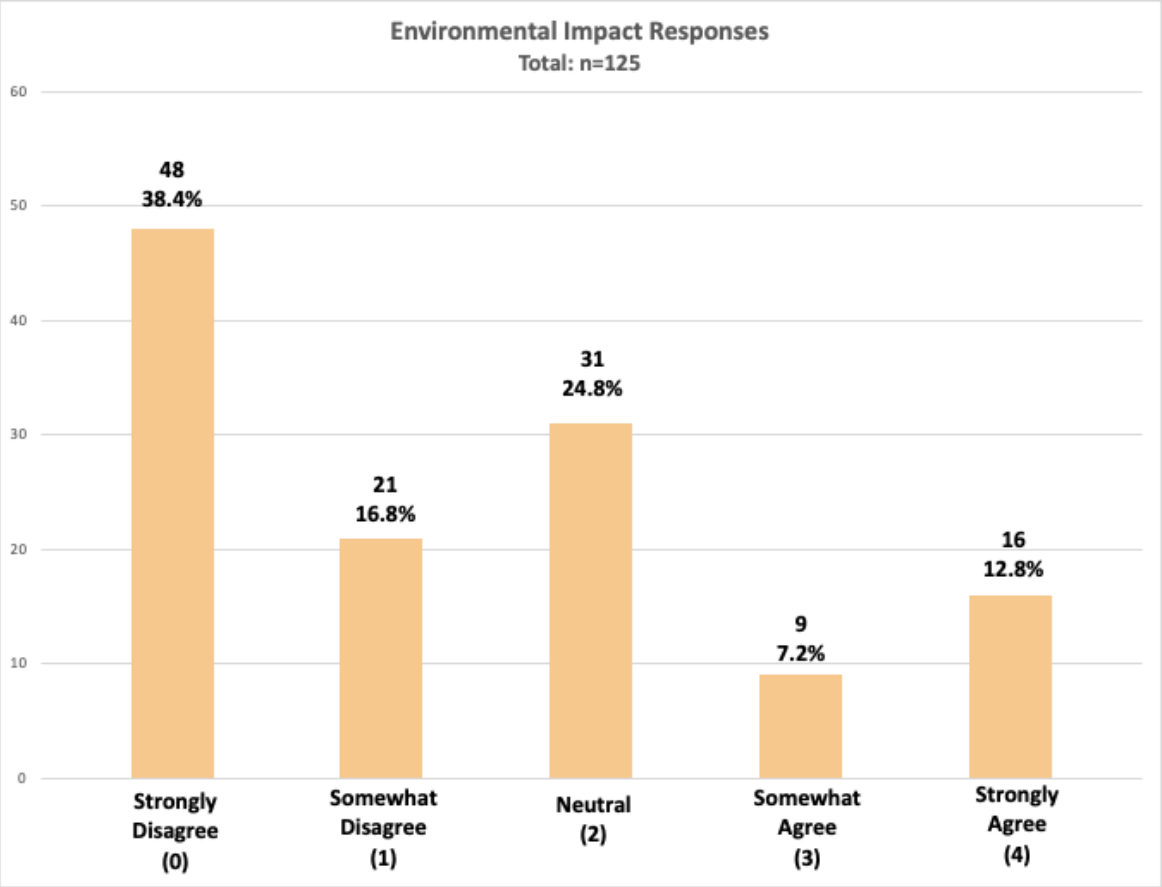

Figure 39: Environmental Impact Responses for Beer

The beer culture and market in Albania is still expanding.

Although the domestic beer market may currently be stagnant, the overall beer culture and market in Albania is expanding. Through interviewing various bars and restaurants, the team learned that beer culture is still relatively new in Albania in comparison to other countries. Different varieties of beer are gaining popularity with Albanian consumers, which may be shifting the market towards craft beers.

Albanian bars mainly choose their beer selection based on what is popular with consumers. However, a few of the bars we interviewed, including Illyrian Saloon and Duff Sports Bar, serve specialty beers to accommodate a small niche market of beer enthusiasts. The manager of Illyrian Saloon remarked that it did not serve many of the popular foreign beers, such as Heineken or Corona, as it has been working to establish a niche beer market at the bar since it opened in 2016. The managers of these two bars expect that the craft beer market will expand in Albania and gain popularity among consumers.

Every bar stated that foreign beers are higher quality than those produced in Albania. Cheers was the only establishment we spoke to that sells a commercial Albanian beer. It sells bottled Birra Korça because of its longstanding history in Albania, but it does not specifically advertise it because of their focus on other brands.

The expanding beer market may begin to favor environmentally friendly beers.

While the majority of Albanian beer consumers we included in our survey sample do not prioritize the environmental impact of the beer they drink, 20% of our respondents did consider this an important factor in their beer purchases. As the Albanian beer market expands, this consumer base may also grow, improving the market for sustainably produced Albanian beer. Bar owners from Cheers and Illyrian Saloon both commented that consumers could receive sustainably brewed beers well if their quality and taste is comparable to other popular beers. The owner of Illyrian Saloon further explained that some beer consumers are willing to invest in specialty beers. Should the consumer base for sustainably brewed beer grow, Albanian breweries may be influenced to implement processes with a lower environmental impact in order to appeal to these consumers.

5.0 RECOMMENDATIONS AND CONCLUSION

The intent of this section is to provide SHUKALB and Albanian breweries with a set of recommendations and areas of future research concerning brewery waste management practices in Albania. The recommendations take into account our research in Albania and the United States.

5.1 RECOMMENDATIONS FOR SHUKALB

Develop a Public Education Program Regarding the Environmental Impact of Brewing Beer

Based on survey data, the majority of Albanian beer consumers do not consider the environmental impact of the beer they drink. The team believes a public education campaign on the environmental impacts of brewing beer could alert consumers to more environmentally friendly brewery practices. SHUKALB could educate consumers on the environmental disruption brought on by wastewater and solid waste. This would help promote environmental awareness in Albania and influence consumers' purchasing preferences to support more sustainable companies. Our project deliverable for SHUKALB (see Appendix L) acts as a summary of findings that lends itself to this recommendation. As discussed in the background chapter, a brewery may be able to sell its beer at a higher price if consumers recognize and value its sustainable practices. The educational program could take many forms, including distributing the deliverable, public events, or an advertising campaign.

Assist Breweries in Implementing Wastewater Treatment

Since WWTPs only treat urban wastewater, with the exception of Birra Korça, it is the breweries responsibility to find alternative methods to treat their wastewater before discharging it into the environment. One of the most effective steps breweries can take to reduce their environmental footprint is to introduce their own personal wastewater treatment infrastructure. The biggest difference we found between American breweries and Albanian breweries regarding wastewater disposal is the wastewater's final destination. While American and Albanian breweries share similar characteristics involving the disposal of wastewater, American brewery wastewater is chemically and physically treated at WWTPs. Albanian breweries do not have an available location to treat industrial wastewater, and therefore have a higher environmental impact by default. While encouraging the government to develop industrial wastewater treatment framework would be an impactful change, the team's research indicates that this is not in the scope of this project or feasible in the near future.

Multiple breweries, including Birra Stela and Gjyshit beer, expressed an interest in developing their own wastewater treatment systems. Because each brewery's process is unique, any wastewater treatment systems they implement will be specific to their brewery and may be any combination of the methods we discussed in Section 2.4 of the background. The biggest obstacles for breweries to overcome when implementing treatment systems are funding and available space. If SHUKALB or a similar organization worked with Albanian breweries to design feasible treatment systems, they may become more interested in implementing them.

Cleaning stages produce the majority of a brewery's wastewater stream. This wastewater has a relatively low organic load and may need little to no treatment if the brewery neutralizes the pH of the water prior to disposal. If breweries separate wastewater with a high organic load (i.e. streams containing spent yeast, wort and trub), they can reduce the volume of wastewater that requires full treatment. The team acknowledges that this recommendation requires resources and collaboration between Albanian breweries and outside organizations, but it could significantly reduce the environmental impact of Albanian breweries and change the operating standards in Albania.

Perform a Cost Benefit Analysis for Wastewater Treatment Implementation in Breweries

The team determined that performing a cost benefit analysis for implementing a brewery wastewater treatment system, as well as analyzing its environmental benefits, was outside the scope of this project. However, this information would still be valuable for Albanian breweries and may help them determine if implementing a system is feasible for their company. A cost benefit analysis should include expenses relating to construction, operation and maintenance, and should also consider the pay-off period for the system. If the treatment system produces high quality water that it can recycle back into the brewing process, the brewery may also reduce its water consumption costs. Every brewery requires a unique treatment system, thus this recommendation requires collaboration with an Albanian brewery.

In addition to saving funds, the analysis should consider the potential environmental benefits of these new treatment processes and account for the intrinsic value associated with preserving natural resources. We acknowledge that it is difficult to quantify environmental benefits that would directly occur from implementing sustainable practices, as brewery waste mixes with other industrial waste discharge. Results from this analysis

should help determine if it is feasible and worthwhile for Albanian breweries to invest in treating their wastewater.

Advocate for Further Regulation of Industrial Wastewater

Under the current system, when breweries are applying for environmental permits the government requires them to list how they treat each waste. Breweries also have the option to write "No Further Treatment" for wastes they do not treat. This option means that the company applying for the permit must work with local authorities to direct this waste to the appropriate disposal locations. This often includes the sewer for wastewater, which, except for Korçë, means brewery waste discharges directly into rivers and the environment. If the Ministry of the Environment were to require on-site waste treatment, such as water neutralization or wastewater treatment, it could mitigate some of the environmental impacts beer brewing produces.

Figure 40: Aeration pond at Vlorë *WWTP. Taken on November 1, 2019.*

5.2 RECOMMENDATIONS FOR BREWERIES

Integrate Environmentally Friendly Practices in Renovation and Expansion Plans

We recommend that Albanian breweries integrate environmentally friendly practices in their renovation and expansion plans, specifically water reuse and reduction processes. Practices such as reusing water from heat exchangers and the pasteurization process, and cleaning with CIP systems all allow breweries to reduce their water consumption. These systems must be integrated into the brewery's production equipment, so it would be easier for breweries to implement these upgrades as they change their processes and production layout. The team recognizes that doing this may be expensive, but given that water is a high operation cost, these options could ultimately save a brewery money. Breweries such as Birra Tirana and Birra Korça indicated to the group that they are either completely renovating or expanding their brewery, and as time goes by, other breweries will eventually need to update equipment as well. Considering sustainable practices through renovations could allow for cost savings in addition to reducing a brewery's environmental impact.

Reuse Spent Yeast, Hops and Trub as Animal Feed

Based on the team's background research, farmers can use spent yeast, hops, and trub byproducts as a supplement to animal feed. Given that these wastes from Albanian breweries are in semi liquid form, brewers or farmers themselves can add these byproducts to the spent grain to supplement the nutrients. The combination of the grain with the waste dilutes the mixture, which decreases the risk of side effects in animals due to the chemical composition of the waste, as the team mentioned in section 2.2 of the background. This would ensure the yeast, hops and trub are not sent into the sewer system and allow for the animals and in turn farmers to benefit from food with increased nutrition.

Reuse Spent Hops and Trub as Soil Fertilizer

Given the high concentration of nitrogen in the hops and trub waste, agricultural industries can employ it as a soil fertilizer or conditioner. The waste, which brewers generally send down drains, has the potential to be put into containers that farmers can pick up, much like the

spent grain systems every brewery currently implements. The recycling of this waste could potentially help the growth of crops for farmers and reduce the environmental impact of breweries.

Package Beer in Reusable Containers

Birra Korça, Birra Tirana, and Birra Puka all collect and reuse their already sold bottles and kegs. Their processes for collecting and returning their old containers is proving to be very successful, however, this process cannot be done with cans. While asking Albanian breweries to stop selling cans may not be feasible, asking them to encourage their consumers to purchase glass bottles or kegs could be much more effective. Big Mountain Brewing Company uses a similar method to encourage its consumers to be more environmentally friendly. Other Albanian breweries that are not recycling their glass bottles and kegs should look into implementing this into their brewery because it could reduce operational costs for purchasing new bottles and kegs.

Switching from plastic to paper labels for packaging is another efficient step to remain more environmentally friendly. Paper decomposes much quicker in the environment when compared to plastic. Birra Stela, for example, has recently switched its packaging materials from plastic to paper.

Install Wastewater Treatment Systems

After seeing what is included in a brewery's wastewater discharge, and knowing that wastewater treatment plants in Albania do not treat industrial wastewater, we recommend that Albanian brewers consider treating their own wastewater. Both Birra Stela and Birra Korça openly expressed an interest in treating their own wastewater in the future. Section 2.4 from our background chapter lists several possible treatment methods, ranging from chemical, biological, physical, and post-treatment. Implementing any of these treatment options would greatly reduce the impact the brewery's wastewater has on the surrounding environment.

Collaborate with Other Industries

From our Albanian brewery interviews and tours, the team saw that none of the breweries fully treat their wastewater before they dispose of it. Birra Korça was the only brewery that was directly connected to a wastewater treatment plant, so every other brewery discharges its wastewater to the environment without treatment. Breweries could reduce their environmental impact by partnering with neighboring industries and work together to construct collective wastewater treatment processes. Birra Stela expressed interest in working with other neighboring companies to create an onsite wastewater treatment plant, similar to the wastewater treatment plant the Coca Cola factory in Tirana employs. Implementation costs may vary depending on how many industries wish to participate and the type of treatment process they wish to assemble. This collaboration would distribute implementation costs among the involved companies and reduce the environmental impact of multiple industries all at once.

Reduce and Reuse Water

Albanian breweries should install water efficient equipment wherever possible and consider reusing water within the brewing process. As discussed in the background chapter, not all steps of the brewing process require high quality water. For example, breweries can use cleaning water from brewing vessels to wash the outsides of bottles in the packaging line. Reusing water can reduce the brewery's operating cost, reduce the volume of water that must be treated, and ultimately reduce the brewery's environmental impact. Breweries may face high initial costs when installing or changing equipment to reduce or reuse water, but these investments may be offset by lower water costs.

Advertise Sustainability Initiatives

Even though the consumer surveys indicated that the majority of our sample did not prioritize the environmental impact of a beer when purchasing it, twenty four percent of respondents did consider it an important factor. The bars the team interviewed such as Illyrian Saloon and Duff Sports Bar indicated that this market has the potential to grow in the coming years. Reuse procedures such as sending spent grain to farmers, recycling yeast, and recapturing carbon dioxide are all features that breweries could promote. In the United States, advertising the sustainability of a beer is a main driving factor for some brewery marketing campaigns, such as Redemption Rock Brewing Company. Albanian breweries may be able to engage their consumers and gain a competitive advantage over other beer brands by advertising their sustainable practices.

5.3 CONCLUSION

In conclusion, the team found that Albanian brewery practices are comparable to those of companies around the world. The main disparity between the two groups is the availability of wastewater treatment. For example, in the United States, breweries send their wastewater to municipal facilities that fully treat the wastewater, both physically and chemically. Breweries in Albania, except for Birra Korça, cannot connect to WWTPs. This means Albanian breweries have a higher environmental impact by default, as their wastewater enters ecosystems without treatment. This investigation determined that Albanian breweries are responsible for their own waste treatment, where initial costs and return on investment are the driving factors for them to both innovate and change. As industrial production develops in Albania due to its growing economy, and water scarcity becomes a more prevalent issue in some areas due to climate change effects, it will become increasingly important for industries and individuals to reduce and reuse water. Given our research, we hope that Albanian breweries will consider adopting practices that have less of an environmental impact in the future.

6.0 LIMITATIONS

While the project team worked to meet all planned objectives, there were a few aspects of each that we were not able to fully execute. The team did not achieve these tasks due to lack of time, resources, and natural disasters. This chapter is meant to summarize these limitations.

BREWERIES

Our goal was to visit at least three large breweries and at least five microbreweries/pub breweries. The team ended up visiting four large breweries and three microbreweries/pub breweries. While we were still able to visit seven total breweries, sparse contact information and lack of operating breweries limited the number and type of breweries we were able to tour. Members of SHUKALB scheduled interviews through mutual connections with the breweries. The team was reliant on these connections to contact breweries, as reaching them otherwise was not feasible. This means that the information in this project may not be representative of all Albanian breweries, as the majority we toured were large scale establishments.

There were four total breweries that the team was unable to meet with. Both the group and SHUKALB could find no information online, including location and contact information, for King Pils Brewery. Birra Norga declined to meet for an interview and tour, and Birra Lissus had closed the previous year. Lastly, Birra Elbar turned out to be a satellite company of Heineken that uses high gravity beer. High gravity beers contain concentrated wort that's watered down to reach the concentration the brewer desires. This means that the factory for Birra Elbar in Gjirokastër did not actually produce beer itself or on the premises.

RESTAURANTS

As stated in section 3.4 of our methods chapter, we planned to interview both bars and restaurants that serve beer to gauge the attitudes of owners and consumers towards more sustainably brewed beer. We had also planned to distribute beer consumer surveys at these locations, as well. We were only able to interview and distribute surveys at bars in the Tirana area known as Blloku, as our sampling technique relied on convenience. This area of Tirana is known to be a more affluent area, so this may contribute bias to our survey. All restaurant owners we approached declined our interview invitation and did not give us permission to distribute our surveys. Even with these limitations, our investigation acquired meaningful interviews and distributed surveys at bars to receive over 70 paper surveys.

ONLINE SURVEYS

As mentioned in section 4.6 of our findings chapter, SHUKALB emailed the online surveys to its personal mailing list. The original plan was to email the online surveys two separate times to ensure completion and a higher number of participants. The team closed the first survey after three days of activity, with the intent of resending the survey with the same process to obtain more responses. Unfortunately, SHUKALB was only able to send the survey out once due to the earthquake in Durrës that lead to a national state of emergency. SHUKALB did not send the surveys out a second time as their partners were working to establish ground teams to help with water utility damage, meaning their attentions were justifiably elsewhere. The team did not question and fully supported this decision, so we did not push the issue further. While we received a smaller sample size than we originally hoped for, the survey results were sufficient, as we received around 60 responses from the first email distribution.

COST BENEFIT ANALYSIS

The team had originally planned to include various costs for waste recycle, reuse, and treatment methods that we had found for our Sustainable Process Research Chart (Table 4) from section 3.2 of our methods. These costs would have included installation costs, return on investment, and how much it could reduce operation costs. The team consulted budget results, company websites, and academic articles along with our U.S. and Albanian brewery tours to obtain information, but we still could not find adequate specifics for this information. Each implementation method had various sizes, features, and add-ons that change the price and feasibility of the method. Singular machines did not apply to all breweries, as each brewery has different needs. When the team asked Albanian brewers about expenses or implementation costs for equipment, they did not know the answers since they were not directly involved with the finances. Consequently, we were unable to complete the sustainable process research chart. The team still highly recommends that SHUKALB or future projects develop a cost benefit analysis that would pertain to specific breweries. This would determine what sustainable practices are feasible and worthwhile for Albanian breweries to invest in relating to treating, reusing, or recycling their waste.

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APPENDICES

APPENDIX A: INFORMED CONSENT SCRIPT

Introduction:

We are engineering students from Worcester Polytechnic Institute (WPI) in Massachusetts, USA. Over the next seven weeks we are working with SHUKALB to better understand Albanian brewery practices for managing wastewater, spent grains, and yeast. SHUKALB is an organization for wastewater and water supply professionals who aim to improve Albania's water practices through education and outreach. We hope to identify options for Albanian breweries to reduce, reuse, and treat their wastewater and reuse spent grains. For our project, we are interviewing wastewater professionals, breweries, and beer consumers. Our team will develop a booklet for brewers with practices that can reduce their environmental impact including benefits, disadvantages, and potential financial savings for each method.

Our university degree requirement requires that we compile our project research in a final report that will be published online by WPI. We can also email the report to you if you wish. Do we have permission to quote you in this report? If not, would you prefer to remain unidentified?

Do we have permission to take photographs of your facilities as part of our research? Are there parts of your facilities that you prefer we do not photograph? These photographs will help us better understand your brewing processes and allow the team to understand how Albanian breweries differ from American breweries.

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 a question, let us know and we will try to clarify. You can also stop the interview at any time. Do you have any questions for us before we begin the interview?

Date: _____

Start/End 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)	

APPENDIX B: INTERVIEW QUESTIONS FOR WATER SECTOR ORGANIZATIONS

1. Demographic Data:
    a. Age
    b. Gender
    c. Job title
2. What is your role within your organization?
    a. How long have you worked for your organization?
    b. How has your role changed over the years?
3. What is the core mission of your organization?
4. Which regulations do you enforce?
    a. Who do you regulate?
    b. When were these regulations developed? By whom?
        i. How long have they been in effect?
        ii. How was wastewater/water supply regulated before these were put in place?
5. How are they monitored?
    a. How do businesses/industries deal with a lack of municipal waste treatment infrastructure (when it is not available)?
    b. How could regulations/infrastructure be improved to better accommodate businesses and industries?
    c. How could businesses and industries improve their processes to better follow regulations?
6. How does the permitting system work?
    a. How do industries obtain operating permits?
7. How do businesses/industries without a connection to municipal systems manage their waste?
    a. Has infrastructure been able to keep pace with industrial development?
    b. What consequences do businesses/industries face for not following regulations?
8. Are you familiar with beer breweries and their system?
    a. If it's different from the above questions:
    b. What permits do breweries need in order to operate?
    c. What do these permits entail?
    d. How are these regulations monitored?
    e. How are the regulations enforced?
    f. Who makes these regulations?
    g. What are the penalties for not following them?

APPENDIX C: INTERVIEW QUESTIONS FOR WWTPs

1. Demographic Data:
    a. Age
    b. Gender
    c. Job title
2. What is your role within your organization?
    a. How long have you worked for your organization?
    b. How has your role changed over the years?
3. How does the wastewater treatment process work here? (ask for a tour)
    a. How long has this particular process been in place?
4. How do you monitor the effluent?
    a. How has it changed, and are there plans for change in the future?
    b. If so, what changes would you implement?
5. What geographical areas do you treat wastewater from?
    a. Do you treat rural, urban, or industrial water?
6. What is the capacity of your treatment facility?
7. What challenges does your organization face (regarding amount of waste, funding, or general operations)?
8. What percentage of businesses/industries are connected to municipal water systems?
    a. How has this percentage changed over the years?
    b. Has infrastructure been able to keep pace with industrial development?
9. How do businesses/industries without a connection to municipal systems manage their waste?
    a. What consequences do businesses/industries face for not following regulations?
10. Are you familiar with beer breweries and how well their practices follow regulations?
    a. If yes, what can you tell us about them?
    b. Are breweries connected to municipal systems?

APPENDIX D: PAMPHLET FOR ALBANIAN BREWERS (ENGLISH)

Our Work with U.S. Breweries

Before travelling to Albania, we visited several U.S. breweries to learn about their brewing processes and how they are working to reduce their impact on the environment. We also learned about what challenges they face.

Through our interviews, we found that most U.S. breweries are connected to municipal sewer systems. Many breweries work with local farmers to reuse their spent grains. Others reuse yeast and water. Some craft breweries have also taken steps to use local ingredients and advertise their sustainable practices to consumers

Our Team:

We are all third year engineering students at Worcester Polytechnic Institute in Massachusetts, USA. This project is a part of our coursework this year. We are working with SHUKAlb to understand Albanian brewery practices.

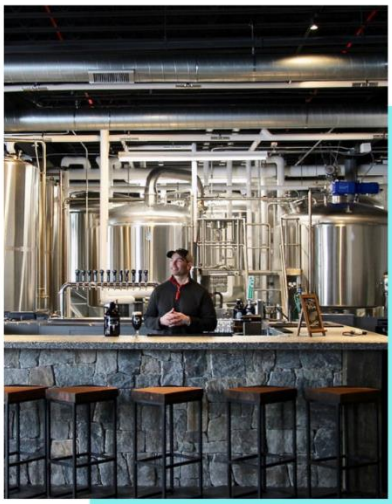
SHUKALB
WATER SUPPLY AND SEWERAGE ASSOCIATION OF ALBANIA

WPI

Greater Good Imperial Brewing Company

Worcester, MA, USA

Greater Good reuses their yeast between batches, which saves money and reduces the amount of organic material they send through the sewer system. Their longest reuse cycle was 6 generations, but on average the yeast lasts for 3 generations. When yeast is finally retired, it goes down the drain with spent dry hops and beer that's deemed unusable.



There are some risks associated with reusing yeast, such as ruining the batch of beer, but these risks are offset by the cost savings. One round of yeast costs $3500. Greater Good would go through this in a week—now they go 1-2 months without buying yeast.

Greater Good harvests yeast by collecting settled yeast and putting it into a yeast kiln. They then keep it in cold storage until they are ready to reuse it. If the yeast is stored for more than a week, it must be fed with dry malt. The yeast performs better when it is used directly after harvest because it is still very active.

Rapscallion Brewery

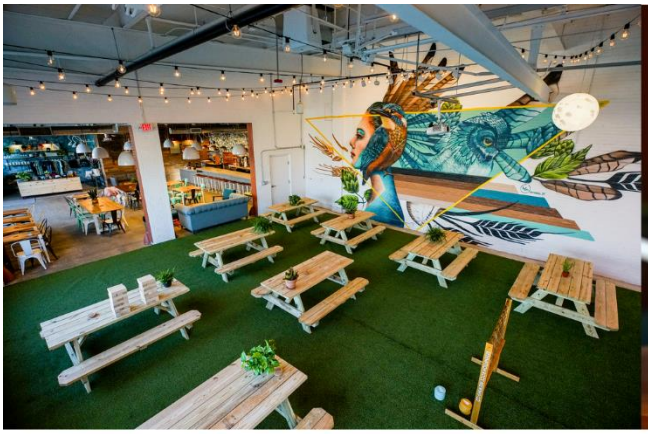
Sturbridge, MA, USA

Rapscallion Brewery uses local ingredients when possible. Even though the beer with local ingredients is more expensive, customers are willing to pay for it. The brewery reduces its environmental impact by only selling their beer in kegs and refillable growlers. Rapscallion Brewery also works with local farmers to reuse their spent grains as animal feed. They reuse their yeast when possible. Rapscallion Brewery's wastewater is stored in a tank outside the brewery and pumped weekly. They try to reduce the amount of wastewater they produce by using low water consumption cleaning sprayers and a closed-loop heat exchanger.

Wormtown Brewery

Worcester, MA, USA

Wormtown Brewery produces over 41,000 hectoliters of beer per year. After their boiling process, their spent grains are drained to be as dry as possible and sent into a silo located just outside their facility. Farmers come by once or twice a week to pick up their spent grains and use them as animal feed fillers to cut down on food costs. This process allows Wormtown Brewery to save money by not paying to dispose of their spent grains because farmers pick them up for free. In return, these farmers save money by having to buy less food for their livestock. This silo is very low maintenance and does not have to be cleaned very often.



Redemption Rock Brewing Co.

Worcester, MA, USA

Redemption rock aims to source from local and ethical companies in order to cut down on carbon emissions, and work to divert and reduce their waste in a number of ways. Their main goal is to decrease their landfill waste as much as possible. To achieve a near zero landfill waste, all glasses, plates and silverware are either reusable or made of organic materials which can be used for compost. They try to recycle and reuse all possible materials in their brewery and are currently working on a way to recycle their grain bags. In regards to their brewing process, some of their spent grains are dried and used as an ingredient to make crackers that are sold and distributed inside their brewery.

The spent grain that is not used for crackers is sent to local farms for feed filler and receive fresh dairy products in return. They have a regular "swap system" with local cafes and bakeries where these places provide Redemption rock with fresh juices, baked goods, and cheese to use in their own cafe, and Redemption returns their containers fully cleaned. Redemption Rock goes above and beyond to be one of the most sustainable businesses in Massachusetts.

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Marissa Gonzales
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APPENDIX E: PAMPHLET FOR ALBANIAN BREWERS (ALBANIAN)

Puna Jonë Me Birraritë Amerikane

Para se të udhëtonim në Shqipëri, vizutuam disa birrari amerikane për të mësuar rreth proceseve të tyre të krijimit të birrës dhe se si ata po punojnë për të zvogëluar ndikimin e tyre në mjedis. Në mësuam gjithashtu se me çfarë sidash ata përballen.

Nëpërmjet intervistave tona, ne morem vesh që shumica e birrave në USA janë të lidhura me sistemin e kanalizimeve komunale. Shumë birrari punojnë me fermer lokal për të ripërdorur farërat e shpenzuara. Të tjerë ripërdorin maja dhe ujë. Disa birrari kanë marrë gjithashtu hapa për të përdorur përbërës lokal dhe për të reklamuar praktikat e tyre të qendrueshme tek konsumatorët.

Ekipi Ynë:

Ne jemi të gjithë studentë të inxhinierisë së vitit të tretë në Institutin Politeknik të Worcester në Massachusetts, USA. Ky projekt është një pjesë e kurseve tona këtë vit. Ne jemi duke punuar me SHUKALB për të kuptuar praktikat.

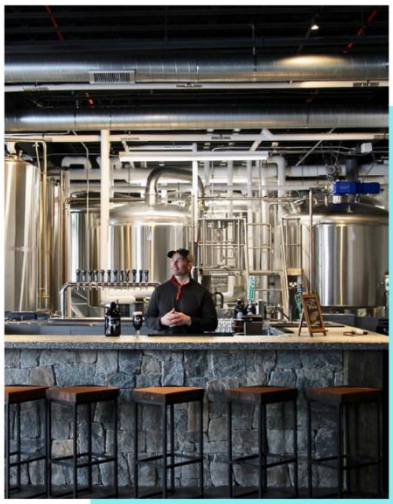
SHUKALB
WATER SUPPLY AND SEWERAGE ASSOCIATION OF ALBANIA

WPI

Greater Good Imperial Brewing Company

Worcester, MA, USA

Kompania “Greater Goods” ripërdorin majanë e tyre midis ndërmjet disa porcioneve, e cila kursen para dhe redukton sasinë e materialit organik që dërgohet në sistemin e kanalizimeve. Cikli më I gjatë i ripërdorimit ka qenë 6 cikle, por masatarisht majaja zggjat për 3 cikle. Kur majaja më në fund mbaron ciklin e jetës, ajo kullon poshtë së bashku me elbin e thatë dhe me birrë që konsiderohet e pa përdorshme.



Ka disa rreziqe që lidhen me ripërdorimin e majasë, sic është prishja e serisë të birrës, por këto rrisqe kompensohen nga kostot e kursyera. Një cikël i majave kushton 3500 dollarë. “Greater Good” mund ta përdorte këtë për një javë - tani ata e përdorin 1-2 muaj, pa blerë maja.

Greater Good korrin maja duke mbledhur majanë e grumbulluar dhe duke e vendosur në një furrë majaje. Ata mund ta mbajnë atë në një depo të frohtë derisa ata të jenë gati për ta ripërdorur atë. Nëse majaja është e depozituar për më shumë se një javë, ajo duhet ushqyer me malt të thatë. Majaja performon më mirë kur përdoret direkt pas korrjes sepse është akoma shumë aktive.

Rapscallion Brewery

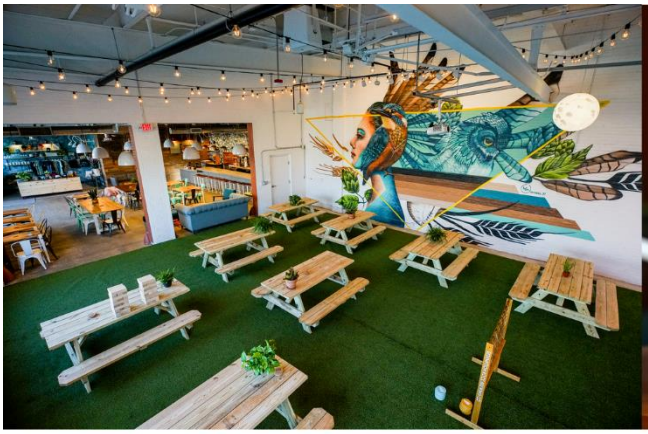
Sturbridge, MA, USA

Birraria Rapscallion përdor përbërës lokal kur është e mundur. Edhe pse birra me përbërës lokal është më e shtrenjtë, konsumatorët janë të gatshëm të paguajnë për të. Birraria redukton impaktin në mjedis duke e shitur birrën në bucela ose bidona qelqi të ripërdorshme. Birraria Rapscallion gjithashtu punon me fermerë lokal për të ripërdorur farërat e përdorura si ushqim për kafshët. Ata ripërdorin majanë e tyre kur është e mundur. Uji i ndotur i birrarisë Rapscallion depozitohet në një depozitë jashtë birrarisë dhe merret me pompë çdo javë. Ata përpiqen të reduktojnë sasinë e ujërave të ndotura që prodhojnë duke përdorur spërkatës që pastrojnë me sasi më të vogël uji dhe një shkëmbyes nxehtësie me qark të mbyllur.

Wormtown Brewery

Worcester, MA, USA

Birraria Wormtown prodhon më shumë se 41,000 hektolitra birrë në vit. Pas procesit të tyre të vlimit, farërat e shpenzuara janë aq të thara sa të jetë e mundur dhe dërgohen në një sillos që ndodhet shumë afër fabrikës së tyre. Fermerët vijnë një ose dy herë në javë për të marrë farërat e përdorura dhe për ti përdorur si plotësues për ushqimin e kafshëve për të ulur kostot e ushqimit. Ky proces i lejon Birrarisë Wormtown që të kursejë para duke mos paguar për depozitimin e farërave pasi fermerët i marrin ato falas. Në kthim, këto fermerë kursejnë para duke qenë se blejnë më pak ushqim për bagëtitë e tyre. Ky silos është me mirëmbajtje shumë të ulët dhe nuk ka pse të pastrohet shumë shpesh.



Redemption Rock Brewing Co.

Worcester, MA, USA

Redemption Rock synon të ketë burimin nga kompani lokale dhe etnike në mënyrë që të reduktojë emetimet e karbonit, dhe punon që të largojë dhe reduktojë mbetjet e tyre në disa mënyra. Qëllimi kryesorë i tyre është të ulin sasinë e mbetjeve që dërgohen në vendet e depozitimit sa më shumë që të jetë e mundur. Për të arritur një sasi thuajse zero të mbetjeve që dërgohen në vendet e depozitimit, të gjithë qelqurinat, pjatat dhe enët e kuzhinës janë gjithashtu të ripërdorshme ose të përbëra nga materiale organike të cilat mund të përdoren për kompostim. Ata përpiqen të riciklojnë dhe të ripërdorin të gjithë materialet e mundshme në birrarinë e tyre dhe aktualisht janë duke punuar për të ricikluar qeset e tyre të farërave. Në lidhje me procesin e birrarisë, disa nga farërat e përdorura thahen dhe përdoren si përbërës për të bërë biskota të thata që shiten dhe shpërndahen brenda birrarisë së tyre.

Farërat e shpenzuara që nuk përdoren për biskota dërgohen në ferma lokale për tu përdorur si plotësues ushqimi dhe në këmbim merren produkte të fresketa. Ata kanë një sistem të rregullt shkëmbimi me kafene lokale dhe furra buke ku këto vende i sigurojnë Redemption Rock lëngje të freskëta, prodhime brumi të freskëta dhe djathë për ti përdorur në kafenetë e tyre dhe Redemption rikthen kontenjerët plotësisht të pastër. Redemption Rock shkon lart e me lart për të qenë një nga bisnezet më të qëndrueshëm në Massachusetts.

Sarah Boermeester
Marissa Gonzales
Katy Jessop
Griffin St. Onge

gr-SHUKAlb-B19@wpi.edu
+355 69 260 5364

APPENDIX F: INTERVIEW QUESTIONS FOR BREWERS

1. Demographic Data:
    a. Age
    b. Gender
    c. Job title
2. When was the brewery founded?
    a. When did you start working at the brewery?
3. How has the brewery changed since you started working here?
    a. How has production changed?
    b. Amount of beer produced?
    c. Process changes? Have you implemented any new processes over the years?
        i. Why did you make those changes?
4. Are there any old pictures of the brewery?
5. Where/how has your beer been marketed?
    a. What types/how many types of beer does your brewery produce at this facility?
    b. Which beers are most popular?
6. How much beer (volume) does the brewery produce each year?
    a. How is the beer packaged (cans, bottles, kegs)?
    b. Where do you distribute to?
    c. Who are your largest consumers (individuals, restaurants, bars, etc.)?
7. How does your brewing process work? (Ask for a tour.)
8. Where do you draw water from for the brewing process (municipal, well, surface, etc.)?
    a. How much water do you use?
    b. Do you anticipate that water will become more expensive?
        i. How might this influence your water usage?
9. Are you concerned with the quantity or quality of the water supply?
    a. Do you think the water quality impacts the quality of your beer? If yes, in what ways?
    b. Do you pretreat or test the water before you use it?
10. Tell us about how you manage your wastewater.
    a. How have your management practices changed?
    b. How much wastewater does the brewery produce (per liter of beer produced)?
11. Tell us about how you manage your solid waste.
    a. How much solid waste does the brewery produce (per liter of beer produced)?
12. What parts of the brewing process produce the most wastewater?
    a. How and where do you dispose of your wastewater?
    b. What process streams are a part of your wastewater?
    c. Do you treat your wastewater?
        i. If yes, how?
    d. How much does it cost to dispose of your wastewater?
    e. What challenges do you face when disposing of wastewater?
        i. How does cost factor in?
        ii. How does municipal infrastructure (or lack of) factor in?
13. How and where do you dispose of your solid waste (spent grains, spent hops, yeast)?
    a. Do you reuse or treat any of your solid waste?
    b. How much does it cost to dispose of your solid waste?
    c. What challenges do you face when disposing of solid brewery waste?
        i. How does cost factor in?
        ii. How does municipal infrastructure (or lack of) factor in?
14. Do you treat any of your waste products before disposing of them? (such as drying the grains, adding water to chemicals, etc.)
    a. If yes, how?

15. What is the most expensive part of your brewing process?
    a. If you were to plan improvements, which parts of the brewing process would you focus on first and why?
16. How does sustainability and the environment factor into your brand?
    a. Would you be willing to learn more about waste treatment, reuse, or reduction methods that are currently being used by other breweries?
17. What parts of your process are you most interested in improving?
    a. What would encourage you to invest in process improvements?
18. Do you think you could sell your beer at a higher price if it was more sustainably brewed?

APPENDIX G: PAPER VERSION OF BEER CONSUMER SURVEY (ENGLISH)

Circle the age range that best describes you:	18-20 21-30 31-40 41-50 51-60 60+
Circle the gender that you identify with:	Male Female Prefer not to answer
Circle the number of beers per week you consume on average:	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15+

Based on the statements below, check one box to rank the level of which you agree or disagree with each statement. Only one ranking per statement. If you prefer not to answer a question, check the box that says "Not Relevant/Prefer Not to Answer" and move to the next statement.

Statement	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree		Not Relevant/ Prefer Not to Answer
I purchase a brand of beer because it costs less than other brands.	☐	☐	☐	☐	☐		☐
I purchase a brand of beer because I know it has a lower environmental impact than other brands.	☐	☐	☐	☐	☐		☐
I drink Albanian beer more than foreign beer because it was brewed in Albania.	☐	☐	☐	☐	☐		☐
I drink Albanian beer more than foreign beer because it is cheaper.	☐	☐	☐	☐	☐		☐
The design of the beer packaging influences what beer I buy.	☐	☐	☐	☐	☐		☐
I am more likely to drink beer that I see in advertisements on TV or around town.	☐	☐	☐	☐	☐		☐
I am more likely to buy a beer that uses local ingredients.	☐	☐	☐	☐	☐		☐
I am more likely to drink beer that my friends and family drink.	☐	☐	☐	☐	☐		☐

WPI SHUKALB WATER SUPPLY AND SEWERAGE ASSOCIATION OF ALBANIA

APPENDIX H: PAPER VERSION OF BEER CONSUMER SURVEY (ALBANIAN)

Qarkoni diapazonin e moshës që ju përfshin:	18-20 21-30 31-40 41-50 51-60 60+
Qarkoni gjininë tuaj:	Mashkull Femer Preferoj te mos pergjigjem
Qarkoni numrin e birrave që konsumoni mesararisht në një javë:	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15+

Bazuar në deklaratat më poshtë, shenoni një kuti për të renditur nivelin e së cilës jeni dakord ose nuk jeni dakord me secilën deklaratë. Zgjidhni vetëm një kategori për deklaratë. Nëse preferoni të mos përgjigjeni në një pyetje, shënoni kutinë që thotë "Jo e rëndësishme / preferoni të mos përgjigjeni" dhe shkoni në deklaratën tjetër.

Deklarata	Nuk pajtohem aspak	Nuk pajtohem disi	Asnjanës	Pajtohem disi	Pajtohem plotesisht	Jo e rëndësishme/ preferoni të mos përgjigjeni
Blej një markë birre sepse kushton më pak se markat e tjera.	☐	☐	☐	☐	☐	☐
Blej një markë birre sepse e di që ka ndikim më të vogël në mjedis se markat e tjera.	☐	☐	☐	☐	☐	☐
Une pi një birrë shqiptare më shumë se një birrë të huaj, sepse është prodhuar në Shqipëri.	☐	☐	☐	☐	☐	☐
Une pi një birrë shqiptare më shumë se një birrë të huaj sepse është më e lirë.	☐	☐	☐	☐	☐	☐
Dizajni i paketimit të birrës ndikon në atë që unë blej.	☐	☐	☐	☐	☐	☐
Unë kam më shumë të ngjarë të pi një birrë që shoh në reklama në TV ose rreth qytetit.	☐	☐	☐	☐	☐	☐
Unë kam më shumë të ngjarë të blej një birrë që përdor përbërës lokalë.	☐	☐	☐	☐	☐	☐
Unë kam më shumë të ngjarë të pi birrë që pinë miqtë e mi dhe familja.	☐	☐	☐	☐	☐	☐

WPI

SHUKALB
WATER SUPPLY AND SEWERAGE ASSOCIATION OF ALBANIA

APPENDIX I: ONLINE QUALTRICS BEER CONSUMER SURVEY (ENGLISH)

Q1. Do you drink beer?

- (●) Yes
- ( ) No

→

Q2. What is your age?

Q3. What is your gender?

- ( ) Male
- ( ) Female
- ( ) Other

Q4. How many beers do you consume per week?

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Click to write Choice 1

← →

WPI

Q5.

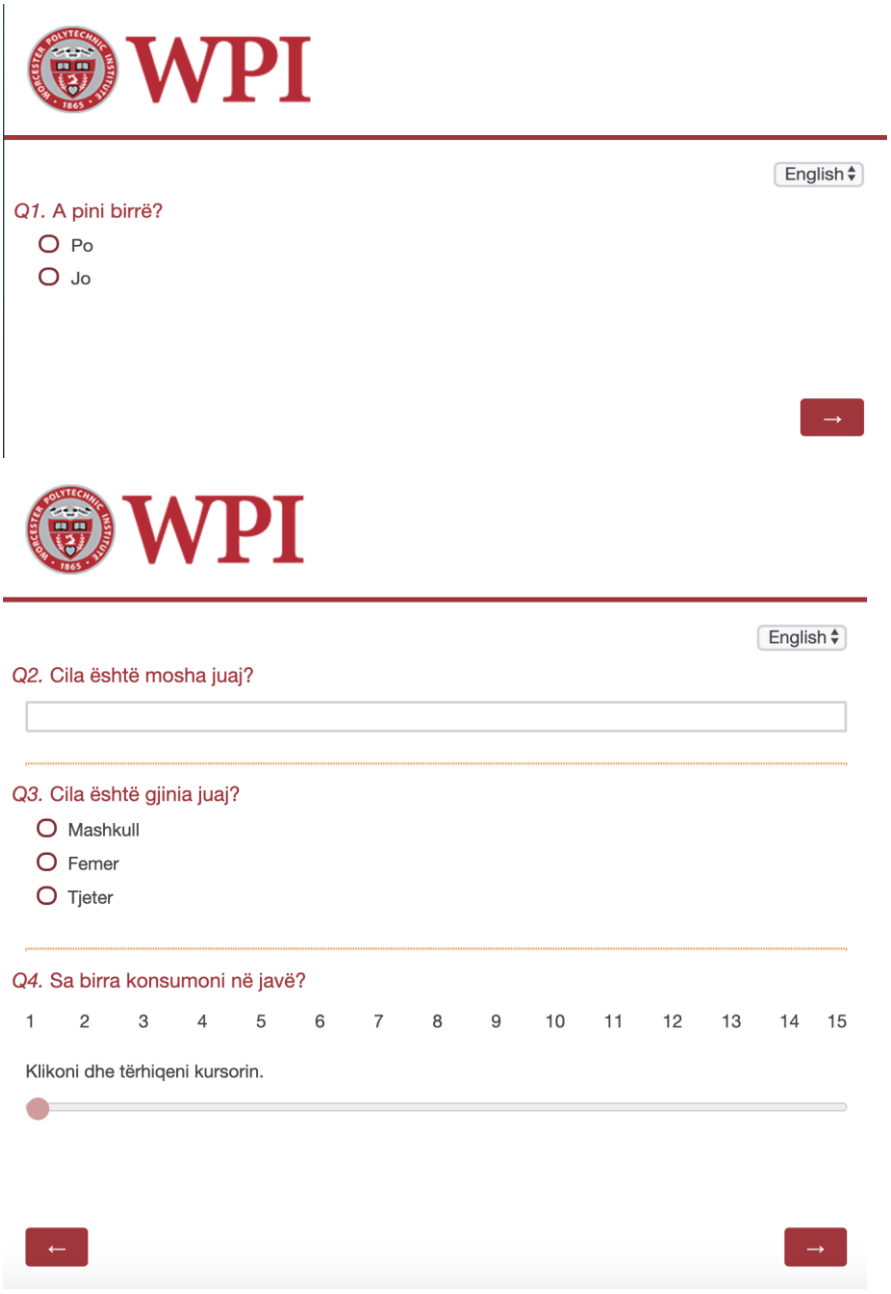
Based on the statements below, check a box to rank the level of which you agree or disagree with each statement. Only one ranking per statement. If you prefer not to answer a question, check the box that says "Not Relevant/Prefer Not to Answer" and move to the next statement.

	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree	Not Relevant/ Prefer Not to Answer
I purchase a brand of beer because it costs less than other brands.	○	○	○	○	○	○
I purchase a brand of beer because I know it has a lower environmental impact than other brands.	○	○	○	○	○	○
I drink Albanian beer more than foreign beer because it was brewed in Albania.	○	○	○	○	○	○
I drink Albanian beer more than foreign beer because it is cheaper.	○	○	○	○	○	○

The design of the beer packaging influences what beer I buy.	○	○	○	○	○	○
I am more likely to drink beer that I see advertisements on TV or around town for more than others.	○	○	○	○	○	○
I am more likely to buy a beer that uses local ingredients.	○	○	○	○	○	○
I am more likely to drink beer that my friends and family drink.	○	○	○	○	○	○

← →

APPENDIX J: ONLINE QUALTRICS BEER CONSUMER SURVEY (ALBANIAN)



English

Q5.

Bazuar në deklaratat më poshtë, shenoni një kuti për të renditur nivelin e së cilës jeni dakord ose nuk jeni dakord me secilën deklaratë. Zgjidhni vetëm një kategori për deklaratë. Nëse preferoni të mos përgjigjeni në një pyetje, shënoni kutinë që thotë "Jo e rëndësishme / preferoni të mos përgjigjeni" dhe shkoni në deklaratën tjetër.

	Nuk pajtohem aspak	Nuk pajtohem disi	Asnjanës	Pajtohem disi	Pajtohem plotesisht	Jo e rëndësishme/ preferoni të mos përgjigjeni
Blerë një markë birre sepse kushton më pak se markat e tjera.	○	○	○	○	○	○
Blerë një markë birre sepse e di se ka një ndikim më të ulët në mjedis sesa markat e tjera.	○	○	○	○	○	○
Unë pi birrë shqiptare më shumë sesa birra e huaj sepse u krijua në Shqipëri.	○	○	○	○	○	○

Une pi një birrë shqiptare më shumë se një birrë të huaj sepse është më e lirë.	○	○	○	○	○	○
Dizajni i paketimit të birrës ndikon në atë që unë blej.	○	○	○	○	○	○
Unë kam më shumë të ngjarë të pi një birrë që shoh në reklama në TV ose rreth qytetit.	○	○	○	○	○	○
Unë kam më shumë të ngjarë të blej një birrë që përdor përbërës lokalë.	○	○	○	○	○	○
Unë kam më shumë të ngjarë të pi birrë që pinë miqtë e mi dhe familja.	○	○	○	○	○	○

←

→

APPENDIX K: INTERVIEW QUESTIONS FOR RESTAURANT AND BAR OWNDERS

Name of Restaurant/Bar: _____
Location: _____

1. Demographic Data:
    a. Age
    b. Gender
    c. Job title
2. How long has your restaurant/bar been open?
    a. What do you enjoy about the restaurant/bar business?
    b. What is your customer base?
    c. How long has your restaurant/bar been serving beer?
3. How many different beers do you sell?
4. Which beers do you sell?
    a. Do you ever change the beers or add new beers?
        i. If yes, how often?
        ii. If yes, why and how do you choose new beers?
5. Do you sell any seasonal beers? Which ones?
6. What are the most popular beers sold in your restaurant?
    a. What is different about the more popular beers?
        i. Are they cheaper, more mainstream, etc.?
7. Do you ever sell out of a beer? Which one?
8. How do you choose which beers to sell?
    a. Do you include popular beers, local beers, foreign beers?
9. There are cases in America where consumers spend more money on beer brewed more sustainable. How do you think your customers would perceive a more sustainably brewed beer?
    a. How willing would you be to stock beer that is sustainably brewed?
    b. How much more do you think your customers would be willing to pay for sustainably brewed beer (if at all)?
10. How do you think your customers would perceive a beer brewed with local ingredients?
    a. How willing would you be to stock beer brewed with local ingredients?
    b. How much more do you think your customers would be willing to pay for beer brewed with local ingredients (if at all)?
11. Do you know where brewery waste in Tirana ends up?
    a. Yes: Would you like to see a change in brewery waste disposal?
    b. No: If they are curious, let them know. If not, no need to push anything on them.

APPENDIX L: SHUKALB DELIVERABLE BOOKLET

ASSESSING OPPORTUNITIES
TO REDUCE THE

ENVIRONMENTAL IMPACT OF BREWERY WASTE IN ALBANIA

06 | 12 | 2019

SHUKALB
WATER SUPPLY AND SEWERAGE ASSOCIATION OF ALBANIA

WPI

/ 01 /

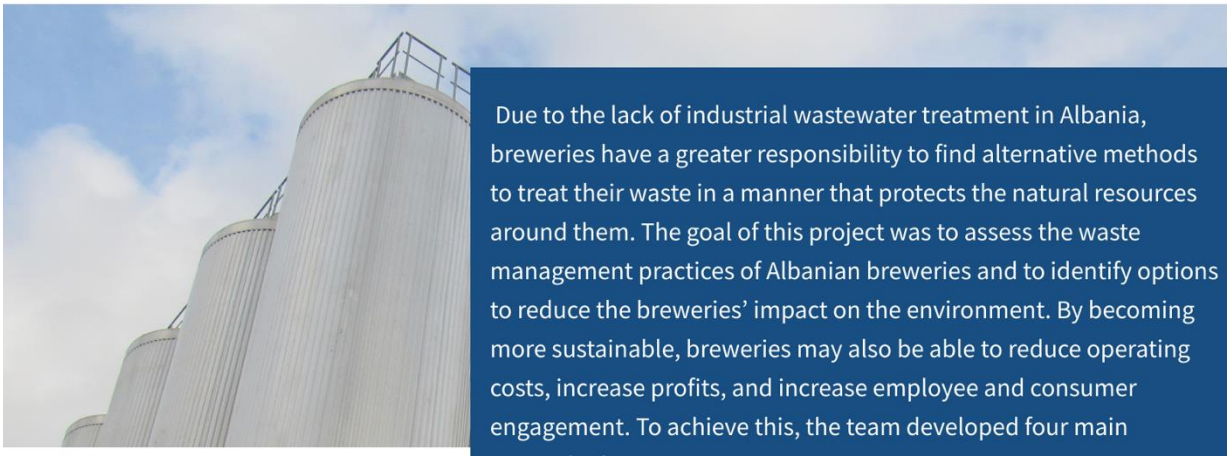
INTRODUCTION

Volumetrically, beer is the third most consumed alcoholic beverage in Albania behind wine and raki, and the beer market is only growing. Brewing beer consumes large amounts of water and produces waste streams that have the potential to significantly harm the environment. As the Albanian brewing industry grows, beer breweries will become a more significant contributor to waste streams, but the extent of which is unknown. The brewing process produces both wastewater and solid waste in the form of spent grains, spent hops, yeast, and trub. Brewery wastewater by itself has a high organic load and negatively impacts receiving water bodies and ecosystems. Solid waste contains nutrient-rich organic materials that disrupt aquatic ecosystems when they decompose.

Three of the ten urban wastewater treatment plants (WWTPs) in Albania are not in operation due to a lack of technical and financial support— the remaining treatment plants have the capacity to treat approximately 25% of the country's wastewater (United Nations Economic Commission for Europe, 2018). The Albanian government has not implemented any industrial wastewater treatment infrastructure. Due to the lack of framework, breweries and other industries do not treat their wastewater before discharging it directly to the environment. 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.

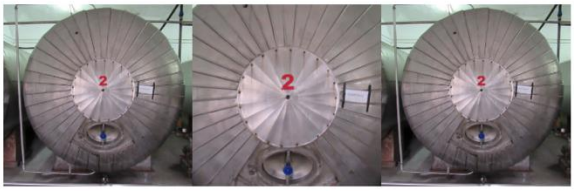
/ 02 /

PROJECT OBJECTIVES



Due to the lack of industrial wastewater treatment in Albania, breweries have a greater responsibility to find alternative methods to treat their waste in a manner that protects the natural resources around them. The goal of this project was to assess the waste management practices of Albanian breweries and to identify options to reduce the breweries' impact on the environment. By becoming more sustainable, breweries may also be able to reduce operating costs, increase profits, and increase employee and consumer engagement. To achieve this, the team developed four main research objectives:

1 Assess wastewater systems near breweries to characterize the collection, treatment and disposal of brewery effluent.

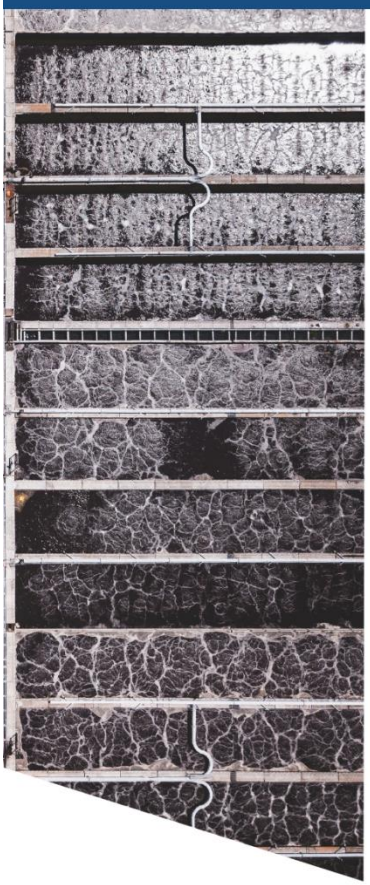


2 Assess how sustainable production processes can reduce operational costs for breweries.

3 Evaluate current brewery waste management practices and their impact on the surrounding environment.

4 Characterize beer consumer purchasing preferences to determine if consumers value a more sustainably brewed beer.

To examine current water supply and waste treatment infrastructure, the team interviewed professionals from the wastewater sector. Interviews addressed the procedures and challenges associated with regulating brewery wastewater discharges. The team also toured Albanian WWTPs to determine what water treatment technologies are used in Albania, how breweries connect to municipal systems, and if WWTPs are capable of treating brewery wastewater.



INTERVIEWS

Polytechnic University of Tirana	Oct. 22, 2019
Water Regulatory Authority	Nov. 29, 2019
Vlorë Wastewater Treatment Plant	Nov. 1, 2019
Korçë Wastewater Treatment Plant	Nov. 15, 2019
AKUM	Nov. 22, 2019
Ministry of Tourism and Environment	Nov. 26, 2019

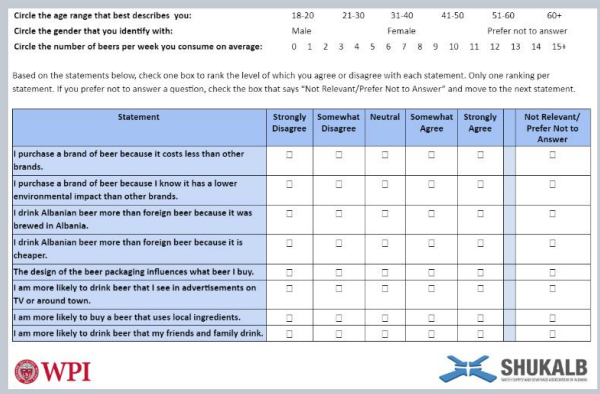
The team researched waste treatment, reduction, and reuse methods adopted by breweries in other countries to identify sustainable production processes that can reduce operational costs in breweries. Prior to traveling to Albania, the team visited and interviewed breweries in Massachusetts. The information we gained from these breweries provided us with a baseline for the project, which we used to compare Albanian breweries to in our findings. This information also gave us examples of possible brewery waste management methods and taught us what we should focus on for our tours and interviews with Albanian breweries.

AN INFORMATIONAL PAMPHLET ABOUT NEW ENGLAND BREWERIES WAS GIVEN TO ALBANIAN BREWERS

To evaluate brewery waste management practices, the team toured seven breweries of varying scales and interviewed brewers in Albania. During the brewery tours, the team requested to photograph the brewery's processes and used these photos to compare Albanian brewery processes to U.S. breweries. The combination of brewery tours, interviews, and photo documentation helped us characterize current Albanian brewery practices and identify where breweries can most significantly improve their practices to reduce their environmental impact. Our interviews with breweries also illuminated what factors, such as operation costs and market competition, limit or drive Albanian breweries to invest in process improvements.

BREWERY TOURS

Bräuhaus	Pub	Nov. 11, 2019
Birra Stela	Large	Nov. 12, 2019
Birra Korça	Large	Nov. 15, 2019
Birra Tirana	Large	Nov. 19, 2019
Birra Kaon	Large	Nov. 19, 2019
Birra Puka	Micro	Nov. 21, 2019
Birraria e Gjyshit	Micro	Nov. 25, 2019



Circle the age range that best describes you: 18-20 21-30 31-40 41-50 51-60 60+

Circle the gender that you identify with: Male Female Prefer not to answer

Circle the number of beers per week you consume on average: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15+

Based on the statements below, check one box to rank the level of which you agree or disagree with each statement. Only one ranking per statement. If you prefer not to answer a question, check the box that says "Not Relevant/Prefer Not to Answer" and move to the next statement.

Statement	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree	Not Relevant/ Prefer Not to Answer
I purchase a brand of beer because it costs less than other brands.	☐	☐	☐	☐	☐	☐
I purchase a brand of beer because I know it has a lower environmental impact than other brands.	☐	☐	☐	☐	☐	☐
I drink Albanian beer more than foreign beer because it was brewed in Albania.	☐	☐	☐	☐	☐	☐
I drink Albanian beer more than foreign beer because it is cheaper.	☐	☐	☐	☐	☐	☐
The design of the beer packaging influences what beer I buy.	☐	☐	☐	☐	☐	☐
I am more likely to drink beer that I see in advertisements on TV or around town.	☐	☐	☐	☐	☐	☐
I am more likely to buy a beer that uses local ingredients.	☐	☐	☐	☐	☐	☐
I am more likely to drink beer that my friends and family drink.	☐	☐	☐	☐	☐	☐

WPI SHUKALB

BEER CONSUMER SURVEYS AND INTERVIEWS WITH BAR OWNERS

In the United States, breweries advertise their sustainable practices to market their beer. We wanted to know what factors influence how Albanians purchase beer and if a brewery's environmental impact had any role in it. To determine this, we employed a five-point Likert scale survey, shown above. We asked consumers how much they agreed or disagreed with different factors of purchasing beer (i.e. price, packaging, sustainability), where zero indicates strongly disagree, two indicates neutral, and four indicates strongly agree. SHUKALB distributed an online version of the survey to its general mailing list and the team distributed a paper version to customers at four bars in Tirana. We chose bars through convenience sampling as we could only distribute surveys with the owner's permission. We also interviewed management from the establishments to gauge their attitudes towards serving more sustainably brewed beer.

REGULATIONS AND PERMITTING PROCESS

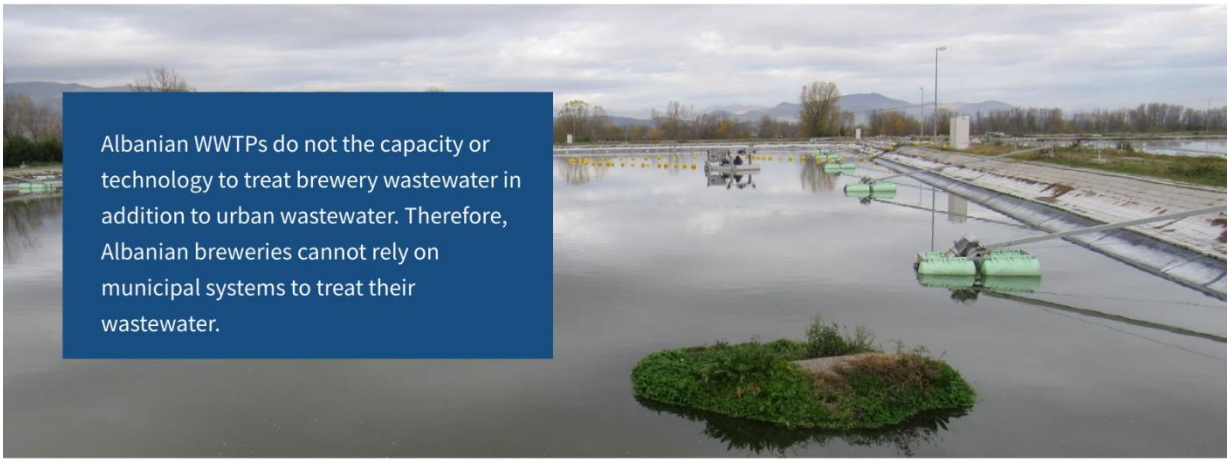
Through the interviews with wastewater treatment professionals, the team found that breweries must maintain an environmental permit from the Ministry of Tourism and Environment to obtain a license to operate. This permit specifies how the brewery must treat, reuse, or dispose of its waste, and details the brewery's plans to manage materials and equipment. In the section of the document that requires breweries to communicate how they plan to handle waste streams, they often list "no further treatment" as an acceptable response for wastewater discharges. The brewery must then coordinate with local authorities to properly dispose of its wastewater. Given the lack of industrial wastewater treatment infrastructure in Albania, breweries generally discharge their wastewater directly to the environment (Personal Communication, Ministry of Tourism and Environment, Nov. 26, 2019).

To maintain their environmental permits, Albanian breweries must self-monitor their operations and report to the National Environmental Agency every six months. Each brewery must contract a certified lab to test the water, air, and solid emissions from its processes. The brewery sends the results from these tests to the NEA to show it is in compliance with its environmental permit. If the brewery is not in compliance with the permit, the Environmental Inspectorate monitors the brewery's operations on site. The Ministry of Tourism and Environment can issue fines to the brewery and possibly revoke its operating license if it does not comply (Personal Communication, Ministry of Tourism and Environment, Nov. 26, 2019).

WASTEWATER INFRASTRUCTURE IN ALBANIA

The team toured Vlorë WWTP and the Korçë WWTP to assess the current state of wastewater infrastructure in Albania. Vlorë WWTP is the newest facility in Albania and only pretreats the wastewater it receives before diverting it to a neighboring canal. It treats urban wastewater from the city of Vlorë but not industrial wastewater.

Korçë WWTP is Albania's most developed treatment facility. It treats effluent from the city of Korçë and also receives wastewater from Birra Korça. According to Korçë WWTP employees, the facility's effluent meets Albanian discharge standards. The status of the remaining Albanian WWTPs, according to regulatory officials, fall closer to Vlorë WWTP than Korçë WWTP. Five of the seven breweries the team interviewed are located in Tirana, where there is no municipal wastewater treatment.



Albanian WWTPs do not the capacity or technology to treat brewery wastewater in addition to urban wastewater. Therefore, Albanian breweries cannot rely on municipal systems to treat their wastewater.

ALBANIAN BREWERY PRACTICES

WASTEWATER

From the brewery tours, the team found that none of the seven Albanian breweries fully treat their wastewater before discharge. Three of the breweries (Birra Korça, Birra Tirana, and Birra Stela) neutralize the pH value of their wastewater before discharge using mixing and balancing tanks. None of the breweries remove organics or suspended solids from their wastewater. Birra Korça sends its wastewater to the Korçë WWTP for further treatment.

SPENT GRAINS

Nearly all Albanian breweries, except for Birraria e Gjyshit, reuse their spent grains by distributing them to farmers for animal feed. Larger breweries, such as Birra Tirana, Birra Stela, Birra Kaon, and Birra Korça, profit from selling their spent grains to farmers, which is something the team had not observed before during its U.S. brewery tours. Five of the seven Albanian breweries reuse their yeast for multiple generations. All of the breweries mix their spent yeast, spent hops, and trub with their wastewater and send it down the drain.

WATER REDUCTION AND REUSE

Five of the seven Albanian breweries have implemented CIP systems to clean their equipment. CIPs reuse caustic and acid cleaning chemicals and reduces the amount of water needed in the cleaning process. All Albanian breweries have also implemented low water consumption spray nozzles to clean their tanks. These nozzles increase water pressure and spray the cleaning solution in all directions to reduce the number of rinses necessary to clean the tank. Almost all Albanian breweries, except for Birra Puka and Birraria e Gjyshit, have closed loop heat exchangers. The breweries reuse hot water produced from cooling hot wort in the mashing step for the following batch. Lastly, Birra Kaon, Birra Tirana, and Birra Stela all recycle water within their pasteurization sections.

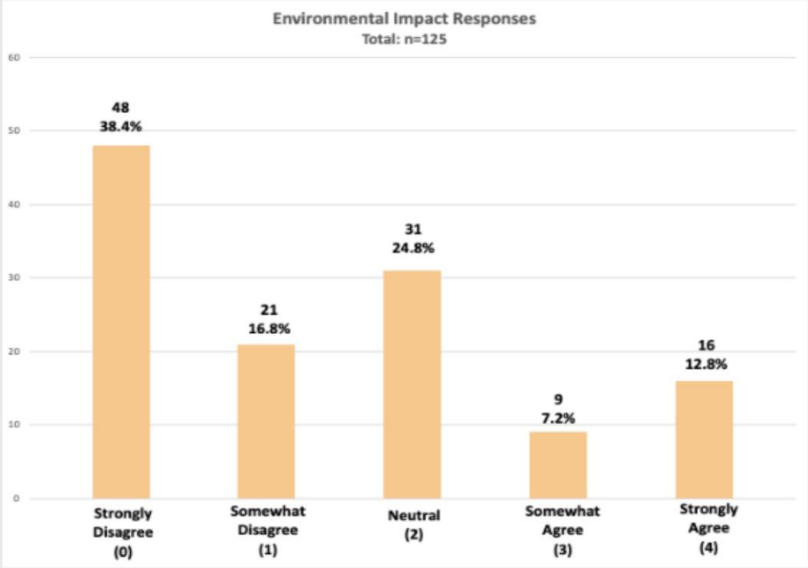
OTHER WASTE REUSE

All Albanian brewers collect and recycle their glass bottles, kegs, or both. While the group had not anticipated it, we found that several Albanian breweries recover CO_2 yeast produce during the fermentation stage and reuse it in the packaging stage to adjust the levels of CO_2 in matured beer for quality and standardization purposes. This eliminates the discharge of CO_2 into the atmosphere, reducing the brewery's carbon footprint. Birra Stela also recycled its plastic waste to produce new packaging and shipping materials. These reuse processes were not the team's original focus, but we found that these procedures saved materials and reduced the overall waste from the breweries.

CONSUMER TRENDS

Through interviewing bar owners and brewers, the team learned that foreign beers are becoming increasingly popular in the Albanian beer market and many domestic brands declining. Additionally, Albanians tend to favor products that are new to the market or favor German and Belgian brewed beers because they perceive them to have a higher quality and different flavor profiles than Albanian beers. Some foreign beers, such as Birra Peja from Kosovo, have become increasingly cheaper to sell in Albania from a lack of import tariff enforcement at Albanian borders and possibly lower production costs in other countries. Declining sales may discourage Albanian breweries from investing in new treatment processes.

In our paper and online survey results, only 20% of consumers indicated that they considered the environmental impact in their decisions to buy a particular brand of beer before they purchased it. Of the rest of the respondents, 49% strongly indicated that they did not consider this an important factor. This indicates that from our sample, while a percentage do consider the environmental impact of a beer, the vast majority do not prioritize it.



CONSUMER SURVEYS

BAR	LOCATION	DISTRIBUTION DATE	# SURVEY	OWNER INTERVIEW
Duff Sports Bar	Blloku	Nov. 12, 2019	19	Yes
Radio Bar	Blloku	Nov. 22, 2019	10	No
Cheers	Blloku	Nov. 23, 2019	16	Yes
Illyrian Saloon	Blloku	Dec. 2-6, 2019	28	Yes

THE TEAM PROVIDED BOTH SHUKALB AND ALBANIAN BREWERIES WITH A SET OF RECOMMENDATIONS AND AREAS OF FUTURE RESEARCH CONCERNING BREWERY WASTE MANAGEMENT PRACTICES.

SHUKALB

A public education campaign would alert consumers of the environmental impacts of brewing beer Albania and influence consumer purchasing preferences to support more sustainable companies. The team also recommended SHUKALB to assist breweries in implementing wastewater treatment systems and perform a cost benefit analysis for waste reuse processes.

DEVELOP A PUBLIC EDUCATION CAMPAIGN

ASSIST BREWERIES IN IMPLEMENTING WASTEWATER TREATMENT SYSTEMS AND PERFORM A COST BENEFIT ANALYSIS

Multiple Albanian breweries expressed interest in developing their own wastewater treatment systems, so with the help of SHUKALB, breweries may be able to fully research and choose which treatment option would be financially worthwhile to invest in. It may even be more feasible for breweries to partner with neighboring industries and work together to construct their own wastewater treatment processes. Birra Stela expressed interest in this during our interview, and it may be more practical for breweries to implement if they could split the cost with other industries.

ALBANIAN BREWERIES

The team recommends that Albanian brewers who are planning to expand or renovate, such as Birra Tirana and Birra Korça, integrate environmentally friendly practices and equipment in their plans. Albanian breweries should install water efficient equipment wherever possible and consider reusing water within the brewing process. Reusing water can reduce the brewery's operating costs, the volume of wastewater, and ultimately the brewery's environmental impact. Breweries may face high initial costs when installing or changing equipment to reduce or reuse water, but these costs may be offset by lower water consumption costs.

Albanian breweries should also recycle their spent yeast, hops and trub as animal feed or fertilizer for local farmers. Larger breweries that are already charging farmers to pick up their spent grains could make additional profits from selling their other solid wastes. Reusing these wastes would decrease the organic matter that is discharged with the breweries' wastewater. The team recommends that breweries begin packaging their beer in reusable containers as well, to cut down on the amount of plastic that makes its way into the environment.

Lastly, Albanian breweries could possibly attract more customers advertising their sustainability processes. Even though the consumer surveys indicated that the majority of our sample did not prioritize the environmental impact of a beer when purchasing it, twenty percent of respondents did consider it an important factor. Bars such as Illyrian Saloon and Duff Sports Bar indicated that this market has the potential to grow in the coming years, so this may be an easy way for Albanian breweries to engage consumers and gain a competitive advantage.

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ABOUT THE TEAM:
We are four engineering students at Worcester Polytechnic Institute (WPI) in Worcester, MA. We completed this project to fulfill our junior year Interactive Qualifying Project (IQP) requirement at WPI.
Learn more at https://www.wpi.edu/academics/undergraduate/interactive-qualifying-project

APPENDIX M: SUMMARY OF U.S. BREWERY INTERVIEW NOTES

Wormtown Brewery

- Produces 35,000 barrels per year. 18-30 batches per week.
- Yeast & Hops:
    - Disposed of through drains and goes into city system. It is possible to mix this in with grains but that would require infrastructure that they do not have.
- Spent grain:
    - Drains out the grain and sends it into a silo to be picked up by farmers. Try to send out as dry as possible. Used as filler to cut down on food costs for farmers.
    - Picked up 1-2 times per week.
    - Will only make a profit off of these if the seller (commodity broker) makes a large profit selling the spent grains.
    - Raw grain silos saved significant amount of money with disposal costs.
    - Silo does not have to be cleaned often; it's all based on turnaround time. Valves are checked for corrosion. B/c they're 'spent grains' a clean tank isn't entirely necessary.
- 5:1-6:1 water to beer ratio.
    - 60 gallons to heat, 30 gallons to mix with chemicals.
    - More water use during the summer (peak brewing time).
    - Have to run cleaning cycle again if tanks not clean enough.
- They buy in bulk to reduce shipping and fuel use involving shipping.
- Growlers are better for the environment but are decreasing in popularity. 5L mini kegs also better for the environment.
- Good reaction from the public involving using local ingredients and sustainability.

Redemption Rock

- Aims to source from local and ethical companies. Allows them to cut down on carbon emissions while shipping and support other local businesses.
- Working to conduct a scope 1 and scope 2 carbon analysis. This allows them to see what areas of operation are creating the most carbon emissions, and they use this to set carbon reduction goals for following years.
- Waste diversion and reduction:
    - Composting: compost bins are accessible to all guests for organic material waste. All food/ beverage ware is compostable to reduce landfill waste produced by the brewery.
    - Can Redemption: do not send cans to municipal recycling facility, instead they take them to a redemption center every week. Donate the money to a non-profit (changes weekly).
    - Spent Grains: all leftover grain is sent to a local dairy farm for food and in return they get local and fresh dairy products to use in the cafe.
    - Wastewater: water efficient equipment.
    - Grain Bag Recycling: Instead of sending grain bags to landfill they are finding a more environmentally friendly solution. Working with other local breweries and Recycling Revolution to recycle the specific type of plastic used for grain bags. (Everything in process).
    - Reuse: tries to reuse any materials possible. Have a regular swap system with Bedlam Book Cafe and Crust Baking for containers that fruit juice, beer cheese, mustard, and baked goods are delivered in. They bring full containers to Redemption Rock and they give them back clean and empty containers. Only a short distance between them so it's an easy transaction.
    - Source Reduction: Maintain a running list of everything they source, what it is made of, where the materials originated from, and the waste that comes with each order. This makes it easy to make a switch to a more environmentally friendly option. For example, switched from disposable bar rags to recycled material that is laundered at a local water and energy efficient laundromat.
    - Waste Reduction: compost, recycling, and landfill bins are weighed every night after closing. This data is used to analyze which areas of their waste stream (landfill, recycling, compost) are the greatest. Waste

reduction goals are set off of this information. They do not have a set waste reduction goal for their second year of operation, but they are in the process of establishing one.

Greater Good

Spent grain:
They dry grain out as much as possible in the lauter tun, then dump it into spent grain bins. This grain is picked up by three area farmers based on their weekly need and our weekly output. They just open the lauter tun up and dump out of man way into spent grain bins, where they wheel it onto loading dock and farmers put it in trucks. There are between 5000 and 8000 pounds of spent grain each week, which is standard for them, and they have created about 567,000 lbs. of spent grain in 2019 so far. Just water that touches the grain, as they extract all sugar and hose it out. The farmers need to come within a time frame, because the grain spoils within 12 hours. The farmers do not pay for the grain, but there's a barter system in place, where they will trade the brewery for milk, meat, and other products, and the brewery will give the farmer some beer. Farmers that come less often get beer; it works like a mutual relationship. There are currently 3 farmers they rely on, if one can't come, they have another on call. It's a pretty reliable system in place. The farmers primarily feed cows, but they also have pigs, and the leftover will go to compost. 100% of the grain goes to farmers, they never throw more than a handful of grain down the drain. If someone spills a large amount (more than a handful), they are required by SOPs to shovel it up into a grain bin. This system has always been in place at Greater Good.

Yeast:
Yeast is reused for several generations as a money saving effort to try to dump less yeast down the drain. When yeast is finally retired, it goes down the drain with spent dry hops and beer that's deemed unusable. The waste is chased with hot water to kill the yeast, and cold water to rinse the drain and avoid clogs. Solids are filtered out by the city's water treatment facility. They mentioned they should be doing cell counts to determine how well the yeast is performing, but they don't. Their longest reuse cycle was six generations, if it gets to third generation and doesn't multiply that's just what happens, and they move forward. They look at the viability of the yeast by taking three samples and finding the average, from which they can determine if it's good for another generation. The yeast affects the beer when it doesn't work, it will develop off flavors, and the yeast will autolyze and create a meaty flavor (tastes like hamburger water), and if there are dead cells in beer and beer gets hot it'll ferment more and explode. Reusing yeast is a much higher cost savings even with the risks, it's $3500 for one round of yeast that they'd go through weekly, but now they go 1-2 months without buying yeast. To harvest the yeast, they take whatever settles and put into a yeast kiln, and keep it in cold storage until they're ready to reuse it, and they have to feed the yeast if it sits for more than a week (dry malt is used for feed). They find the yeast performs better with subsequent use because they take it out before the dry hops are put in, so the yeast can just do their thing without absorbing residue. If they harvest the same day that they pitch the next round of beer, the yeast will still be in log phase, so it's still super active and fermentation starts within a few hours (quicker process).

Chemicals and Waste Water:
Chemicals in solution and the waste water go down the drain and get treated at the water treatment facility. They never dump more than 3 bbl. of chemical at a time so that they don't ring any bells at the water treatment facility. They do dump waste beer daily, but never in large amounts. It also has a more neutral pH than most waste, so it doesn't cause issues.
In the event of a chemical spill, we are required to call the water treatment facility to give them a heads up. If chemicals are dumped in excess and it is traced back to the brewery, they could face heavy fines.
Sustainability:
They are mindful of the waste they create. They're projected to brew 7,000 bbl. this year and upwards of 10,000 bbl. next year. When it comes to cleaning, they reuse chemicals as often as possible. For example, when a fermenter is sanitized, the sanitizer in the tank is backflushed to the transfer line and the heat exchanger so each sanitization cycle only uses about 2 bbl. of the total peracetic acid solution. Acid levels are kept around 350 ppm, which is within the food safe threshold, but not using so much it is considered wasteful. If the levels reach 550 ppm, it gets to be excessive and wasteful. They will reuse caustic for cleaning as long as it does not pick up soils in the cleaning cycle. Usually the same 3 bbl. of caustic solution (2.56 oz caustic/bbl. of water) will be used to clean the kettle, the heat exchanger, and the lauter tun. They will do this often when cleaning our other tanks as well, although it becomes tougher to reuse when cleaning a

dry hopped tank due to the soils.
They are also mindful of their water usage. They are sure to only use exactly as much water to make the beer as needed. When rinsing a tank, it's rinsed in bursts instead of just dumping a ton of water into a tank and in turn, down the drain. They save immeasurable amounts of water this way as they are only using what they need and nothing more. When refilling the large hot liquor and cold liquor tanks, there is always someone watching the water level to avoid overflowing the tanks as much as possible. They do waste a small amount of water, but they make sure to never waste too much.
The Process:
What can you tell us about your current infrastructure and how the process is laid out?

- Is it a manual process or automated?

Overall the process is super manual, the only thing that isn't fully manual is grain out. They climb on top of equipment to put in hops, the milling in is very manual, as it's one person dumping 26 bags into the mill, someone has to add sugars into the kettle. They are looking into purchasing a hop cannon to help with the process a little, it will take longer to clean that out but will be far safer.

Rapscallion

- Produce 1000-1500 barrels per year = 31,000-46,500 gal per year
    - Brew 2 batches per week on average
    - 40-60 gallons left over at the bottom of the fermenters that is disposed of.
- 3000 gal holding tank for their wastewater and spent hops
    - Pumped weekly, $500-600 per pump
- Had to start testing wastewater a few years ago (pH, BOD, COD)
- Try to use local ingredients in their beer
    - Big selling point for consumers
    - Quality is better than mass produced ingredients
    - Consumers don't mind paying a premium for it
    - It's difficult to use all local products because the beer is inconsistent and more expensive.
        - Also, hard to get enough quantity locally
        - They try to keep everything US grown if it's not local
    - Just call people up for ingredients
- Spent grains go to local farmers.
    - They pick it up twice a week within an hour of brewing
    - Fed to cows. Previous farmers had pigs.
    - Hops go to the wastewater storage tank.
- They reuse yeast when they can.
    - Type of yeast used is specific to the beer.
        - Also takes on some of the characteristics of the beer.
    - Needs to be used immediately or stored between batches.
        - Difficult to reuse when a different type of beer is brewed each batch.
- Process
    - Had a closed loop heat exchanger and low water consumption cleaning sprayers.
    - Process was manually operated.
    - Boiler used oil instead of natural gas because they aren't connected to gas lines.
    - Only distribute kegs, no bottles or cans
        - Their restaurants offer refillable growlers to take home.
- They would advertise more if they did more.
    - Don't own the property, so they can't make any structural changes.
    - Trying to reduce the amount of wastewater that goes to the storage tank so they can pump less often.
    - Initial capital to invest in treatment systems is also a problem for small breweries.