ISSN No:-2456-2165

Waste Management and Logistics of Craft Beer Production

Attila Albert
Doctoral School on Safety and Security Sciences
Óbudai University
Budapest, Hungary

Abstract:- During small-scale brewing, the energy demand and the amount of waste generated are very high. In order to reduce these quantities, the methods and materials used in production and their logistics need to be reviewed. Therefore, in my research, I look for the critical points where most waste is generated and try to find alternative methods that help reduce energy demand, waste generated, and transportation costs. I will examine what the Life Cycle Assessment and the Carbon Footprint are and look for a solution to reduce these metrics. I map out the possible recycling opportunities that can be used in brewing processes, especially the recycling possibilities of wastewater, sludge and yeast. I am also looking at alternative waste reduction options for packaging waste, as well as ways to reduce the logistical problems and costs associated with waste management. With this information, small-scale brewing will have the opportunity to create a more sustainable, environmentally friendly production process.

Keywords:- *Craft Beer, Waste Management, Logistics, Sustainability, Recycling.*

I. INTRODUCTION

Brewing is a high energy process. For the industry to be sustainable, renewable energy sources must be involved in production. Life Cycle Assessment (LCA) is a method that allows the environmental impact of a product during its life cycle to be individualized and quantified. As neither small-scale and large-scale brewing can be described as environmentally friendly, especially with regard to the resources used, such as water and energy, some sustainable practices need to be introduced into the brewing process in order to be sustainable [1]. Carbon Footprint (CF) is an indicator of the total amount of direct and indirect emissions of carbon dioxide (CO2) and other greenhouse gases, expressed in carbon dioxide equivalent (CO2eq). The LCA method is often used to calculate this indicator. At present, these indicators are very high in the industry, moreover, in terms of the amount produced, the waste and energy used in small-scale production are significantly higher in specific terms than in large-scale production. In order to reduce these indicators, we need to review production processes and apply new methods that help reduce energy consumption and the amount of waste generated.

II. WASTE MANAGEMENT AND RECYCLING IN THE FOOD INDUSTRY

One of the most important tasks of logistics is the storage, transport and disposal of waste generated during production. The professional, environmentally friendly collection of materials and waste used in production is the task of recycling logistics. CLXXXV of 2012 on waste management. The law is in line with the European Union's environmental policy. This law covers the following activities:
-collection and transport of waste,
-waste management,
-monitoring of these activities,
-activity as a trader or intermediary,
-operation of waste management facilities and equipment,
-Aftercare of waste facilities.

The Waste Act imposes the following conditions on waste management activities:
-the activity must be carried out without endangering human health and the environment
-the activity does not pose a risk to the environmental elements,
-do not cause a nuisance or smell to the public,
-does not adversely affect the landscape, protected natural and cultural values.

The concept of waste is most simply formulated as what is not needed, what is unnecessary, what we put in the trash [2].

The primary goal of the plants is to minimize the amount of waste generated during production. The part of the material used that appears in the finished product is called useful or pure use, and its size is specified by the so-called net norm. In some industries, such as the food industry, a certain amount of raw material in the finished product is an essential condition for the required quality of the product. In these sectors, the raw material content of the finished product is usually set by standards. In such cases, the reduction of clean use degrades the quality of the finished product [3]. In the case of small plants, it is even more important to minimize the waste generated, as the cost of waste management per product will be higher for fewer finished products.

ISSN No:-2456-2165

Not only is waste generated in the food industry during production, but a quarter, or even half, of the quantities produced become inedible even before it reaches the consumer's mouth. The food industry does not aim to reduce food waste generated by households, as these increase their revenues. Although there are campaigns for food waste reforms, producers cannot be forced to produce less waste [4].
Solution options:
- redistribution: mainly redistribution of remaining, surplus raw materials to those in need
- creation of animal feed
- anaerobic fermentation
composting
- heat treatment and energy recovery [5].

In addition, waste generated during production can be used more widely, which can even serve as a raw material in other industries:
1. reuse in the food industry: the resulting by-products can be used to produce another new type of product
- flour: the pulverulent material produced during milling could be used as a food supplement by milling plants, as they are generally of high nutritional value but cannot be used in a given production process.
- colorants: as a natural colorant, food waste can be recovered much more valuable, as opposed to synthetic colorants
- enzymes: enzymes can reduce the chemical load, making production more sustainable, eliminating toxic substances and reducing pollution
2. cosmetics industry: the demand for the use of natural materials has come to the fore in the production of cosmetic products, so food by-products can be used instead of artificial ones
- antioxidant: a very important substance for the human body, so it can be easily replaced by recycling waste from the food industry. It is especially needed by the skin, so it is often used in sunscreens and oils.
3. Pharmaceutical industry: Synthetic antimicrobials, which are used against microorganisms in the pharmaceutical industry, are causing more and more respiratory diseases and infections in human organisms. Thus, the pharmaceutical industry is also open to using natural substances as raw materials for medicines.
- antibacterial and anti-cancer preparations: food by-products are in many cases a source of excellent nutrients and phytochemical compounds for a healthy lifestyle.
antivirals: viral mutations have accelerated in recent years, leading researchers to move towards bioactive ingredients that have high antiviral capacity, reduce the activity of infected cells and inhibit their proliferation [6].

III. MATERIAL AND METHOD

Critical points of waste generation, prevention and recycling

Waste generation from large-scale breweries is outstanding in the food sector, mainly due to wastewater. The energy demand and waste generation of craft breweries is even higher in specific terms than that of large-scale breweries. In the interests of sustainability, logistics supply chains, which in many cases cross countries and continents, should be replaced by local supply chains, thus increasing sustainability. Designing local supply chains can save a lot of transportation costs. Breweries have the option of entering into contracts with their suppliers that oblige suppliers to take back the packaging materials in which the raw materials needed for production are delivered to the plants. This can significantly reduce the waste production of a brewery.

Brewing is divided into several successive operations: malting, grinding, mashing, copying, adding hops or hop extract and boiling the whey, disposing of used hops and precipitated protein, aerating and cooling the whey, fermenting with yeast, removing yeast, conditioning maturation) and packaging. The goal is to convert yeast-derived sugars into simple sugars with the help of yeast, which, when fermented, result in a low-alcohol, lightly carbonated beverage. This production process leads to the generation of large amounts of organic waste [7].

The principle of prevention is paramount in waste management. By choosing the right technologies, processes and materials, many wastes can be significantly reduced. Another important task is the selective collection of recyclable or salable waste. The use of a compactor can also reduce storage space and shipping costs. Alternatively, the possibility of energy recovery by incineration can be explored, which should be preferred to landfill [8]. Amienyo et al. says twelve environmental impacts were studied in relation to beer packaging, taking into account 3 types of packaging methods, which are as follows:
-global warming potential (GWP)
- abiotic depletion potential (ADP)
-acidification potential (AP)
- eutrophication potential (EP)
- human toxicity potential (HTP)
- marine aquatic ecotoxicity potential (MAETP)
-natwater aquatic ecotoxicity potential (FAETP)
- terrestrial ecotoxicity potential (TETP)
-zone depletion potential (ODP)
- photochemical oxidant generation potential (POCP)
energy demand
-water demand
The 3 types of packaging carriers tested:
-steel box
-glass
-aluminum box

Beer in steel cans has the least impact on five of the 12 impact categories considered: primary energy demand, depletion of abiotic resources, acidification, marine and freshwater toxicity. Bottled beer is the worst solution for nine impact categories, including global warming and primary energy demand, but has the least potential for human toxicity. Beer in aluminum cans is the best solution for ozone depletion and photochemical smog but has the greatest potential for human and marine toxicity [9]. Nevertheless, Molina-Besch et al. draws attention to the fact that the indirect environmental effects of packaging are not sufficiently taken into account in current food LCA practice. A more systematic study of indirect environmental effects would be needed to establish a more accurate LCA. In addition, further packaging research is needed to obtain the currently missing empirical data [10].

ISSN No:-2456-2165

Critical points of the brewing process in terms of waste production:

1. Mash, mud

Barley waste can be used as a carbon source during fermentation for the cultivation of microbial biomass, for the production of microbial enzymes, sugars, proteins, organic acids, antioxidants and food additives, or simply as an adsorbent for the removal of organic matter from wastewater and the immobilization of various substances [11]. Barley waste is an excellent source of nutrients for ruminants. Most Hungarian craft breweries consider this recycling option a priority. The waste generated is resold as animal feed. But there are other uses for it. In addition to being reused as food of animal origin, some of its ingredients may be useful as precursors or carbon sources for food chemicals in microbial fermentations:

(a) dietary and nutritional use
(b) commercial and industrial use of microbial products
- o bioethanol production
- o lactic acid production
- o production of xylitol
- o microbial enzyme production
- o protein hydrolyzate production [11]

However, it is worth mentioning that a certain proportion of the remaining beer can be recovered from the remaining mash with different filtration and centrifugation technologies, so there will be less loss.

Pyocyanin is a fluorescent phenazine pigment, bright blue in color, synthesized exclusively by approximately 95% of Pseudomonas aeruginosa strains. Malt pomace is an excellent environmentally friendly alternative in the process of producing pyocyanin in a synthetic medium [12].

2. yeast

Yeast is a very valuable feed due to its high protein, vitamin and mineral content. It is also suitable for human consumption, in which case the yeast must be dried. Yeast, both in suspension and in dried form, is a valuable raw material in the pharmaceutical and cosmetic industries [8].

3. sewage

The high COD value of the used diatomaceous earth into the wastewater must be avoided and due to the suspended solids load. Therefore, it is advisable to recycle diatomaceous earth in all cases, which has many possibilities. Conservation, sterilization, soil improvement, composting, regeneration, building materials industry.

The chemicals entering the wastewater, which are necessary for sterilization and cleaning, must be neutralized. Pomace and yeast do not enter the wastewater using the appropriate technologies. It is important that the label waste does not end up in the wastewater, as this is harmful to the environment as a suspended matter [8].

A zero waste treatment system close to food processing wastewater has been developed and studied. Wastewater was treated with an anaerobic membrane bioreactor (AnMBR), treated with an outdoor photobioreactor to grow microalgae, and excess sludge was treated with hydrothermal carbonization. With this system, all organic carbon in wastewater was reduced by 97%. This method has demonstrated a near-zero waste emission system capable of producing high-quality wastewater, recovering nutrients and carbon into microalgal biomass, and producing energy as biogas and hydrocarbons [13].

4. packaging materials

(a) glass

By reducing glass breakage in the mining industry, the generation of waste can be significantly reduced. It is also more environmentally and economically advantageous to use the largest possible packaging. Although multi-way glass is much more environmentally friendly, it is much more expensive from a logistical point of view, but it would drastically reduce the cost of packaging material. In cases where one-way packaging is unavoidable (eg for hygienic reasons) or proves to be more economical than multi-way packaging, it is advisable to choose packaging that is recyclable (eg paper or glass) or biodegradable (eg paper). These usually reduce the cost of disposal and can sometimes even generate revenue [8].

b) alu box

An excellent alternative to reducing glass production is aluminum cans, which are showing an increasing trend when packaging craft beers. The production of aluminum cans requires more energy than that of glass, but their lower weight allows transport to be optimized. The recycling / reuse of bottles should be encouraged by streamlining the transport of empty bottles to breweries [1].

c) plastic bottles

If in some cases plastic-based one-way packaging is unavoidable, it is advisable to strive for uniform (same material) packaging. If the resulting packaging plastic waste is made uniform (eg only polyethylene films), there is hope for its recovery or sale [8].

Plastic packaging is the least environmentally friendly solution, so it is advisable to avoid this in all cases.

d) KEG

Packaging in KEG barrels is one of the most environmentally friendly solutions. The tanks are multi-way, so they can be used more than once or a significantly larger amount of beer can be transported in one container. However, this requires proper cleaning, which increases the amount of chemicals used. The adversity of recent years has made us realize that although KEG is environmentally friendly, there are times when the volume of beer sold in KEG barrels drops to almost zero, as restaurant and restaurant closures caused by the corona virus almost zeroed out KEG sales worldwide.

(e) alternative options

It is important that the storage device into which the beer enters and travels to the consumer is always clean. This is especially important for recycled devices such as recyclable glass or KEG barrels. If not properly washed and cleaned, there is a risk of infection. Today, the consumption of tank beers is becoming more widespread, which means that beer is taken directly from the factory to the pubs in huge tanks, unpasteurized. Its shelf life is thus greatly reduced, but its enjoyment value is greatly increased due to the omission of heat treatment. To prevent the storage tanks from becoming dirty and having to be disinfected weekly, the factories line the inside of the tanks with a sterile bag and fill the beer directly into these bags, thus avoiding contact with metal surfaces. It can be disposed of after the bag has been emptied, which is reassuring from a food safety point of view, but a concern from an environmental and sustainability point of view.

Waste logistics, alternative, on-site use of waste from brewing: Algae, Biomass, Biorefinery

Algae immobilization remains an open field for different research in different fields. Immobilized algae technology has proven to be very effective in remediation, heavy metal removal, and toxicity assessment. One of the most promising areas of research is the use of this technology to reduce environmental pollution through the biosorption and biodegradation of many harmful compounds. Combinations of solar energy and algae immobilization technologies can be successfully applied in industrial processes, including brewing [14].

Brewery wastewater contains huge amounts of organic compounds that can cause environmental pollution. The microalgae wastewater treatment method is an emerging, environmentally friendly biotechnological process. Microalgae thrive well in nutrient-rich wastewater by absorbing organic nutrients and converting them into useful biomass. Harvested biomass can be used as animal feed, biofertilizer and as an alternative energy source for biodiesel production [15].

There are three main aspects to the success of any sustainable biofuel: technical feasibility; economic viability; and sustainability of resources. Algae-based biofuels are technically feasible. In addition, the sustainability of resources in terms of land, water, nutrient and energy use needs to be carefully quantified for each type of production system so that the raw material is truly “sustainable”. With large-scale biofuel production processes, this hydropower-nutrient relationship is the subject of considerable consideration and debate [16].

Integrating a biorefinery into the production system allows high value-added waste to be recycled and prevents it from being wasted. This makes the process not only economically but also environmentally sustainable, reducing waste generation and resource use. Waste from breweries is an excellent raw material for this [17].

With aerobic and anaerobic biological treatment processes, biogas and biomass can be generated from the waste generated during brewing. There is a very significant potential in the operation of block heating power plants with biogas. By utilizing in this way, the amount of biogas that can be produced from the brewery's waste can cover a significant part of the total energy demand. Biomass would supply a biorefinery [8]. It is important to note, however, that a biorefinery involves a huge investment cost, so it makes sense to bring together several smaller distilleries next to each other and set up the plant together. Installing a biorefinery next to breweries would take huge logistical costs off the breweries, creating much more environmentally friendly and sustainable production, with, of course, greater consideration of environmental impacts.

IV. RESULTS & SUMMARY

In my research, I map out the critical points in the process of artisanal, small-scale beer production from the point of view of waste management and logistics. In terms of waste, there are countless recycling results that are many times more economical, environmentally friendly and sustainable instead of the current useful methods. Of course, the principle of prevention is the most important, but there are cases where this is not possible. In the case of the packaging of the finished product, I examined the most sustainable solution, considering 12 aspects, projected on 3 different packaging materials, but each of them also has advantages and disadvantages. Alltogether, multi-way, high-capacity, high-fracture, but very light glass would be the most environmentally friendly packaging materials in the beer industry, but they don’t exist yet. An alternative could be to use tank circuits in catering units, but this is unsuitable for home use. In most cases, the recyclable food by-products can be recycled. There are numerous solutions for wastewater treatment, a novelty is the treatment with an anaerobic membrane bioreactor, which can reduce the amount of total organic carbon in the water by 97%. Based on the immobilization of algae, it is an open area, carrying it in countless ways. Biomass production and the establishment of a bioprocessing plant for breweries is a whole new field, but there are many potential rejectors in it. It can significantly reduce logistics costs, but at a huge investment cost. The task of the future is to examine the economy and sustainability of such a factory, considering the environmental effects.

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