Distillery waste management

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ANOTACE

Tato práce se zabývá odpadovým hospodářstvím v pěstitelských pálenicích. V teoretické části je rozebrána česká i evropská legislativa, která se týká odpadů a pěstitelských pálenic s následným vymezením pojmu pěstitelské pálenice a popisem generace odpadů v těchto podnicích. V praktické části jsou popsány metody analýzy, následuje případová studie s návazností na komparační analýzu. Závěrem této práce jsou různé návrhy pro využití některých odpadů.

Klíčová slova: pěstitelská pálenice, odpad, odpadové hospodářství, kvas, pecky

ANNOTATION

This thesis is focused on distillery waste management. In Theory Czech and European legislation related to the topic is described. Next the distillery definition and waste generation in distilleries is detailed. In Analysis methods used are described, which is followed by case study and comparative analysis. At the end of this thesis suggestions for waste utilization are made.

Keywords: distillery, waste, waste management, ferment, cores

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I hereby declare that the print version of my Bachelor's/Master's thesis and the electronic version of my thesis deposited in the IS/STAG system are identical.

CONTENTS

INTRODUCTION

Main goal of waste management is to reduce amount of waste produced. It is important to reduce waste amount and to find new ways to utilize as much of waste as possible. Of course the main thought of the waste management is that the best way to manage waste is to not produce it in the first place.

This approach however is not possible in distilleries and therefore, there is need for proper waste management system, which will deal with used ferment, cooling water and other waste types found in a distillery. There are many distilleries and many ways of dealing with this problem and only some of them will be mentioned in this paper.

The topic of this thesis was chosen thanks to the author's practical experience with the distilleries. The author works in a distillery and is familiar with the whole distilling process. Another reason for choosing this topic is that it will be relatively easy for author to obtain data needed for analysis part of the bachelor thesis.

The goal of the thesis is to describe current state of waste management in distilleries, compare this state between the individual distilleries and to suggest some new and creative ways of waste disposal or usage. This thesis aims to describe legislative related to the distilleries and waste management.

Theory will start with Czech laws called "Waste minimization act" and "Spirit drinks regulations". These two laws and their European alternatives will be briefly described. Another part of theoretical part will be identification of waste types themselves. Waste types range from ferment to CO_2 emissions. Basic terminology will also be explained in this part of the thesis.

Practical part of the paper will start with methodology and introduction of the distillery for the case study, which is going to be the main part of the thesis. Another type of analysis that will be used in the thesis is comparison of several chosen distilleries. And at the end of the practical part some suggestions for further usage of some waste types will be stated.

I. THEORY

1 CZECH LEGISLATION

In this chapter and its subchapters there will be shown and explained main legislation concerning waste management. This thesis is oriented specifically on distilleries, which means that only relevant parts of legislation will be digested.

Main legislation includes "Waste minimization act", "spirit drinks regulations", "waste catalogue" and notices adjusting these acts.

1.1 Terminology

1.1.1 Terms - waste minimization act

Waste – According to the law waste is every movable thing, which is being disposed of by an individual. That means that everything unwanted in the subject of our analysis (distillery) is a waste (Zákon č. 185/2001 Sb., o odpadech).

Waste can stop being waste, if it meets these requirements:

a) It has specific use,

b) There is market or demand for it,

c) It meets technical requirements for specific usage given by special regulations usable on products,

d) Usage is in harmony with special regulations and will not harmfully affect environment and human health and

e) It meets other criteria, if they, for this type of waste, exist in EU regulations (Zákon č. 185/2001 Sb., o odpadech).

Dangerous waste is a waste which has at least one dangerous trait described in EU norm about dangerous characteristics of waste (Zákon č. 185/2001 Sb., o odpadech).

Waste management is activity focused on preventing waste production and further care for place where the waste is stored permanently and checking these activities (Zákon č. 185/2001 Sb., o odpadech).

Waste adjustment means every activity that changes chemical, physical or biological characteristic of given waste. It is done for purpose of enabling or simplification of its

transport, usage, removal or for reducing its volume or dangerousness (Zákon č. 185/2001 Sb., o odpadech).

There are actually much more terms in waste minimization act, but they have no value in this work. Chosen ones represent basics of distillery waste terminology and the rest will be stated in next subchapter dedicated to the terminology from spirit drinks regulations (Zákon č. 185/2001 Sb., o odpadech).

1.1.2 Terms – Spirit drinks regulations

For this act alcohol (or spirit drink) means ethyl alcohol produced by distilling or alcohol separated by other means. This alcohol has to be from fermented sugar solutions or from other material containing fermented ethanol (Zákon č. 61/1997 Sb., o lihu).

Faulty ethanol is ethanol which composition does not meet qualitative requirements given by implementation notices (Zákon č. 61/1997 Sb., o lihu).

Measurement is done for one litre of ethanol having 20 °C (Zákon č. 61/1997 Sb., o lihu).

Distillery is a workshop where ethanol is made and falls into one of these categories

a) Industrial distillery,
b) Agricultural distillery,
c) Fruit distillery,
d) Yeast distillery,
e) Sulphite distillery,
f) Chemical distillery,
g) Distillery – this is a special kind which only sells service of distilling others fermented fruit, this type of distillery actually does not exist in most of the world (Zákon č. 61/1997 Sb., o lihu).

Any reference to distillation and distilleries in this thesis will be addressed to the category g.

1.2 Waste minimization act

1.2.1 Act subject

The first and the most important of all acts stated above is "Waste minimization act", which directly affects every type of waste management. In this subchapter there will be explained how relevant parts of this act affect waste management in distilleries. This act adjusts:

a) Rules for prevention of waste production, while conserving human health and sustainable development.

b) Rights and duties of individuals in waste management.

c) Activity of authorities in waste management (Zákon č. 185/2001 Sb., o odpadech).

From this can be told that waste minimization act is focused on preventing waste production. At the beginning of this regulation it is stated what type of waste it does not manages. Only relevant one is that it does not relate to any uncontained pollutants. It is of use because of carbon dioxide emissions, which are subject of another chapter.

1.2.2 Waste management hierarchy

According to the law there is strict hierarchy of managing waste:

a) Prevention of waste production,

b) Preparation for re-usage,

c) Recycling,

d) Other usage of waste, e.g. energetic use,

e) Waste destruction (Zákon č. 185/2001 Sb., o odpadech).

In this thesis the first three points are of no use, it will be targeted to the last two.

1.2.3 Authorities of waste management

There are much more authorities stated in this act, but only a few are relevant to problematics of distilleries. For distilleries they are listed from the most important: Ministry of agriculture, Customs office and Czech business inspection (Zákon č. 185/2001 Sb., o odpadech).

Most of authorizations given to the distilleries are given by Ministry of agriculture, but most inspections are performed by customs office. The reason Ministry of agriculture is included is that they are working on notices adjusting managing of biodegradable waste (Zákon č. 185/2001 Sb., o odpadech).

1.3 Spirit drinks regulations

This norm adjusts the most important thing related to production of spirit drinks. Therefore it is the most important law for distilleries, but for the purpose of this paper it is only on second place, because there is little amount of adjustments regarding waste management, however anything in this act is mandatory for any entrepreneur working in this sphere. This act adjusts conditions for production and modification, additionally storing, records and market circulation of spirits.

1.3.1 Terms for ethanol production and modification

Ethanol can be produced only in those types of distilleries stated above and entrepreneur must own Trade Certificate for running distillery. This certificate can be given to individual by Ministry of agriculture (Zákon č. 61/1997 Sb., o lihu).

1.3.2 Monitoring of drips and drops and some waste products

Whole distilling machine has to be sealed by officials, so every measure of produced ethanol can be measured. In distilleries this is made by Custom office which measures the amount of ethanol produced, by special measuring device. Any damage to the seals must be immediately reported and the seal must be replaced, otherwise sanctions could be made (Zákon č. 61/1997 Sb., o lihu).

Special measuring device, Figure 1

1.4 Waste catalogue

In waste catalogue there are listed types of waste. Important for this work are only two Only two of them are important for this work, summarizing all waste found in ethanol production. These two types of waste found in catalogue are the most important, whole thesis is built around them.

a) 02 03 – Waste from production and processing fruits, vegetables, cereals, edible oils, cocoa, coffee and tobacco; waste from cannery and tobacco industry, production of yeast and yeast extract and from preparation and fermentation of molasses,

b) 02 07 02 – Waste from ethanol distillation (Vyhláška č. 381/2001 Sb., Katalog odpadů).

2 EUROPEAN LEGISLATION

As with any country belonging to European Union, even Czech legislation must have implemented the European one. This chapter will be focused on base directives concerning waste and distilleries. Note that these directives are already implemented in Czech legislation, which means that this chapter will only be a quick summarization of relevant acts and directives.

2.1 Directive 2008/98/EC of the European parliament and of the council on waste and repealing certain directives

Terminology will be excluded from this chapter, because it is the same terminology used in waste minimization act from Czech legislation. Differences were made only in process of translation. The same goes for waste hierarchy, which is described in waste minimization act.

This directive establishes framework for waste management in Community. It defines main concepts such as waste, disposal and recovery. Also this directive puts in place the essential requirements for waste management. It is setting obligation for an establishment and undertaking carrying out waste management operations to have a permit or to be registered (Directive 2008/98/EC, on waste).

Member states have to draw up waste management plans. It is also an obligation to manage waste in a manner, that it does not have negative impact on environment or human health. Also it is said, thanks to the application of polluter pays principle, that the costs of waste disposal must be borne by the holder of waste, previous holders or by producers of the product from which the waste came (Directive 2008/98/EC, on waste).

These two paragraphs were taken from the preamble of the directive, it can be seen, that it really is in an accord with Czech legislation, the same principles and the same requirements are given. In next paragraphs will be shown something more relevant to the topic of distilleries and also commented on.

First notable article from this directive is article 11 which focuses on re-use and recycling. This article encourages Member States to take measures, to promote the re-use of products. It is also stated that Member States should support use of quality recycling (Directive 2008/98/EC, on waste).

Another important article is article 22 which concentrates on bio-waste. Since ferment could be considered as bio-waste. According to the article Member stated should encourage:

a) The separate collection of bio-waste with a view to the composting and digestion of bio-waste;
b) The treatment of bio-waste in a way that fulfils a high level of environmental protection;
c) The use of environmentally safe materials produced from bio-waste (Directive 2008/98/EC, on waste).

"The Commission shall carry out an assessment on the management of bio-waste with a view to submitting a proposal if appropriate. The assessment shall examine the opportunity of setting minimum requirements for bio-waste management and quality criteria for compost and digestate from bio-waste, in order to guarantee a high level of protection for human health and the environment." (Directive 2008/98/EC, on waste)

In general the two legislative documents are almost the same. Whereas the Czech one is more specific, the European one is more universal in some points. That is not surprising, because every Member State adjusts their legislation so it is in accord with the European one. For purpose of this thesis was necessary to compare the two documents.

2.2 Regulation no 110/2008 of the European parliament and of the council

This regulation is focused on the definition, description, presentation, labelling and the protection of geographical indications of spirit drinks. This regulation applies to all spirit drinks placed on the market in the Community even if it is not produced in the community. It also applies to use of ethanol or distillates of agricultural origin in the production of alcoholic beverages. Also adjusts the use of the names of spirit drinks in the presentation and labelling of foodstuffs (Regulation no 110/2008, on spirit drinks).

From all the information given by this regulation are only two relevant to the distilleries which are subject to this thesis. It is that any alcohol meant for consumption or production of spirit drinks must be of agricultural origin. And the second one is that for the alcoholic beverage to be considered spirit drink are a few requirements:

a) It is intended for human consumption;

b) It possesses particular organoleptic qualities;
c) It has minimum of 15 % vol.;
d) And it has to be produced:
    a. Either directly:
        i. By the distillation
        ii. By the maceration
        iii. By the additions of flavourings, sugars or other sweetening products
    b. Or by a mixture of spirit drink with one or more:
        i. Other spirit drinks, and/or
        ii. Ethyl alcohol of agricultural origin or distillates of agricultural origin and/or
        iii. Other alcoholic beverages and/or
        iv. Drinks (Directive 2008/98/EC, on waste).

3 DISTILLERY DEFINITION AND ILLEGAL DISTILLERY PROBLEMATICS

Since there are many distillery types stated in Czech legislation, but not as many in English, this chapter will be dedicated to definition of distillery in this thesis. It is stated in chapters above, that this thesis will work only with one special type of distillery.

First it needs to be indicated that most of the distillery types share their technology and production processes. They do not share however the material type for their production. For example, yeast distillery which produces food alcohol usually uses yeast in order to produce it. Another example is fruit distillery which obviously uses fruits for spirit drink production (Škorvan, 2015).

The type of distillery this thesis will be focusing on could be called subtype of fruit distillery. These subtypes are usually small businesses, which do not produce spirit drinks for sale, but rather sells service of distilling for common people. This is specific to several countries in central Europe which are the Czech Republic, the Slovak Republic and Austria. With this come several regulations and limitations (Škorvan, 2015).

These distilleries are under supervision of customs office and every part of their technology must be sealed by official seals. Special measuring device is in every official distillery which collects small amounts of spirit for later measurements. These measurements serve for correct calculation of consumer tax which is cut in half from other distillery types (Škorvan, 2015).

Additionally every distillery has to have collecting container for drips. Drips are dangerous for human health, because they contain larger amounts of methyl alcohol (and other chemical substances) than are allowed, therefore it must be separated from the rest of spirit drinks. This is possible because these substances have lower boil temperature than ethyl alcohol and therefore starts dripping (hence drips) sooner than the core spirit (Škorvan, 2015).

Drips and drops collecting container attached to collecting tank, Figure 2

Another limitation applies for customers. It is necessary for a client to provide information on where he got the fruit. It is either from his own property, from property lent to him by other person or by perquisites of their employer. Adding sugar or another sugar based additives to the ferment is prohibited. And there is also a limit for amount of spirit that a household can have produced, which is 30 l of pure alcohol (100% ethanol), meaning around 60 l of 50% spirit (Škorvan, 2015).

All this means, that not just anybody can run a distillery and distilling at home or any non-registered distillery is a crime. These homemade and non-registered distilleries are usually called black distillery (Škorvan, 2015).

Even though that number of distilleries that provide service of distilling grows each year, it is still huge problem in the Czech Republic and in Slovakia. Nowadays it is not a crime to own a non-registered distillery, it could be a crime however if the distillery is used to produce enough spirit drinks. Producing unlabelled spirit drink means stealing the states taxes and that is where running a black distillery becomes a crime (Škorvan 2015).

It is impossible to even estimate the number of black distilleries in the Czech Republic, but it is known that there are many. It is not easy for customs office to uncover them, since owning one is not an offense (Škorvan, 2015).

Another problem of these black distilleries is that, people do not know it is illegal to produce their own spirit drinks. And it is often encountered that, people are claiming, that they can produce alcohol for their own purposes (Škorvan, 2015).

Number of distilleries in the Czech Republic is approximately somewhere around six hundred, which is astonishing number in such a small country as the Czech Republic. This

number grows every year as can be seen because in 2009 there were “only” 540 distilleries (Škorvan, 2015).

In appendix P1 is shown map with some distilleries which were manufactured by chosen distillery manufacturers. These manufacturers are J. Hradecký Pacov and Destila Brno. From the map can be seen, that distilleries are quite densely spread across the republic. Only distilleries registered on the site palenice.net are included, since it is hard to keep track of all the new distilleries that are built every year. This map therefore is only for illustration purposes. There is around 600 distilleries today and the total number of distilleries on the map is 124.

These small distilleries are doing a service, for which larger industrial distilleries do not have time. They are needed in central Europe, because it is local custom and tradition to have your own “homemade” spirit drink. And these drinks are usually of high quality (Škorvan, 2015).

4 WASTE IN DISTILLERIES

This chapter will be dedicated to waste types in distilleries. Whole process of fermenting and distilling will be perceived right from the start. That means that waste types will be determined as they can chronologically appear in the whole process.

Normal waste like human excrements, sewer water or communal waste is present also in distilleries. In some special distilleries can be found also some special waste like plastic parts from plastic barrels or fruit remains after crushing it into more easily fermenting mash. In following subchapters will be venue listed waste present in all distilleries.

4.1 Picking up fruit

The whole process of creating quality spirit drink starts already on the tree. Specifically it starts under the tree. To get high quality spirit drink, high quality fruit is needed. Usually it is said that you can use fruit you would eat. Thanks to this is deduced the first waste type and that is unsuitable fruit (Balaštík, 2010, Jílek a Zentrich, 1999).

Fruit can be unsuitable from several reasons. These reasons also lead to different waste. For example fruit can be unripe. This fruit can cause serious problems if put into ferment (higher amounts of toxic methyl alcohol in final product), therefore is should be considered as waste (Balaštík, 2010).

Another reason can be rotten or infected by some kind of disease. This should be obvious, however many people do not understand this. This kind of fruit can affect taste and quality of final product, which means, that it is unwanted and again could be considered a waste (Uher, 1964).

Last problem that can occur “under the tree” is that the fruit should be clean, in this case the fruit is not a waste, but nevertheless the dirt that could be stuck on it would. This one is easily solvable by simply washing the fruit (Balaštík, 2010).

4.2 Fermentation

Next stage in the process is fermentation and naturally it is another source of waste. Fermentation is a biochemical process, which creates from every molecule of sugar two molecules of ethanol, two molecules of carbon dioxide and 88 kJ of energy in form of heat (Balaštík 2010, Jílek a Zentrich, 1999).

First notable waste is CO_2. It could be considered as serious waste, if there is substantial amount of ferment in one room. Such room is present in some distilleries and is called fermentation room. CO_2 emission can be serious and these rooms have special ventilation demands. Ferment can produce amount of CO_2 equal of its own amount in one day in the stormy fermentation (Uher, 1964).

Whole ferment can become waste if it is discarded by some microorganism or an organism normally referred to as the fungus. Among microorganisms are counted bacteria and mould. These microorganisms are put into the ferment with unsuitable fruit. Dirt, mould, or rot can cause partial acidification or complete one. In this case ferment becomes waste (Balaštík 2010, Škopek, 2003).

4.3 Distillation

Even when fermentation process will be without any fault, in this final stage of distilling waste cannot be prevented, but certain types of it could be. Main type of waste is used ferment. And (if from drupe) hard seeds, if they can be separated (Balaštík, 2010).

Another waste is drips and drops. Drips are part of spirit drink, which starts condensing before core spirit. It has slightly different chemical composition then the core spirit, meaning it is not suitable for drinking. Drops are very similar to drips and are also considered waste (Uher, 1964).

Next is waste water, which is used mainly for cooling various parts of distillation technology, those parts are reflux and cooler (they are pretty much the same things, but on different parts of technology). This water is usually heated to around 55 °C and diverted to some kind of collecting container or straight to the sewers (Jílek a Zentrich, 1999).

It might not be considered regular waste, but there is a lot of waste heat, which usually goes away through chimney connected to the kettle. It is a lot of energy, which could be used for another purpose, like heating water or to heat a room (Jílek a Zentrich, 1999).

Last type of waste in this stage is faulty spirit. Faulty spirit can be from several reasons and only a few are then considered a waste a not just low quality spirit drink. If the ferment was fully acidified, then the spirit has smell of the thinner and sharp taste, which are both very repelling. This spirit is then a waste. If the fruit was dirty then the ferment and spirit drink can have acrolein aftertaste, and irritates eyes during distillation, again this spirit drink would be considered a waste (Balaštík, 2010).

Like everywhere where we can find people, even in distilleries there is a communal waste and swill. These are commonly disposed of regularly like in any other building, swill goes to the sewers and communal waste is then put into a bin. Recycling waste is separated and put into its respective bins (Balaštík, 2010).

II. ANALYSIS

5 METHODOLOGY AND DATA

This chapter is dedicated to used methodology in analysis and obtaining data for this bachelor thesis. Subchapter is dedicated to each method that will be named and described. This thesis focuses on waste management in distilleries as explained in theoretical part of thesis, which means that received data are strictly from small businesses focusing on selling their services.

5.1 Data collection

Collection of data is done through several means. The first is personal interview with a willing owner and operator of chosen distillery. Transcript of interview with key informant is attached in appendices. This key informant is vital to the case study of this chosen distillery.

The second way of collecting data is by survey. These data are needed for comparative analysis of waste management in different distilleries.

Another data are obtained through observation and experience. Along with photographic documentation and description of important parts of technology, which are participating in waste management, these data are used for introduction of case study distillery and for explanation of working mechanisms that are important.

All information regarding responders is anonymised due to their requests and to avoid any form of advertising in this thesis. Most of data collected is from Moravskoslezský region and the rest comes from Zlínský or Jihomoravský region.

5.1.1 Key informant

Key informant is in this case owner of small distillery in Moravskoslezský region. This person in qualified in the field of distilling and is familiar with the whole process of waste disposal in his business (Maxwell, 2013).

Data are collected from this person through interview and practical demonstration. This is useful for case study which is the most important part of this thesis. The main advantage of this method is that, the data are collected from an insider, while the main disadvantage is that the informant can be influenced by their own feeling and therefore pass on distorted data (Maxwell, 2013).

5.1.2 Survey

Survey was chosen for its relative ease of use and time friendliness. Most of the surveyed people are owners of small businesses, who were not willing to pass their data in other form. Credibility of obtained data is ensured by anonymization, although it still might not be always credible. The main advantage of this method is its ability to gather specific data and main disadvantage is that self-reported data are usually distorted (Tracy, 2013).

5.1.3 Observation and experience

Observation and experience are two methods that, in this thesis, were used simultaneously. Data collected come from work experience. That means that collected data are the most objective and true, which is its primary advantage. Disadvantage is the time consumed by work and observation (Tracy, 2013).

6 DISTILLERY INTRODUCTION

6.1 Choosing process

Choosing the right distillery for the case study was very important decision, since the majority of analysis is focused on that. Several criteria were applied. And this chapter is dedicated to introducing the chosen distillery.

There are many distilleries in the Czech Republic and each of them is different. Even if technology, location and clientele were put aside, the most important component is workforce. While somewhere the operator is a drunk, there are many distilleries with qualified and responsible workforce.

Criteria were:

- Availability for data collection to be done in person,
- credibility and competency of personnel based on customers reviews,
- presence of fermenting room,
- presence of core removing machine,
- presence of fruit crusher,
- Solid fuel powered kettle.

These criteria were applied to maximize usability of case study and to maximize number of potential waste types covered by it. Not all of those were met, since there was not found such distillery in required distance.

6.2 Introduction

Chosen distillery is located in a small village in Moravskoslezský region. It is operated by its owner, and two of his sons. This distillery is in function since the year 2005 and has been in constant development since. In 2013 fermenting room was completed and in 2014 core removing machine, press and fruit crusher were added. Credible equipment for this thesis includes:

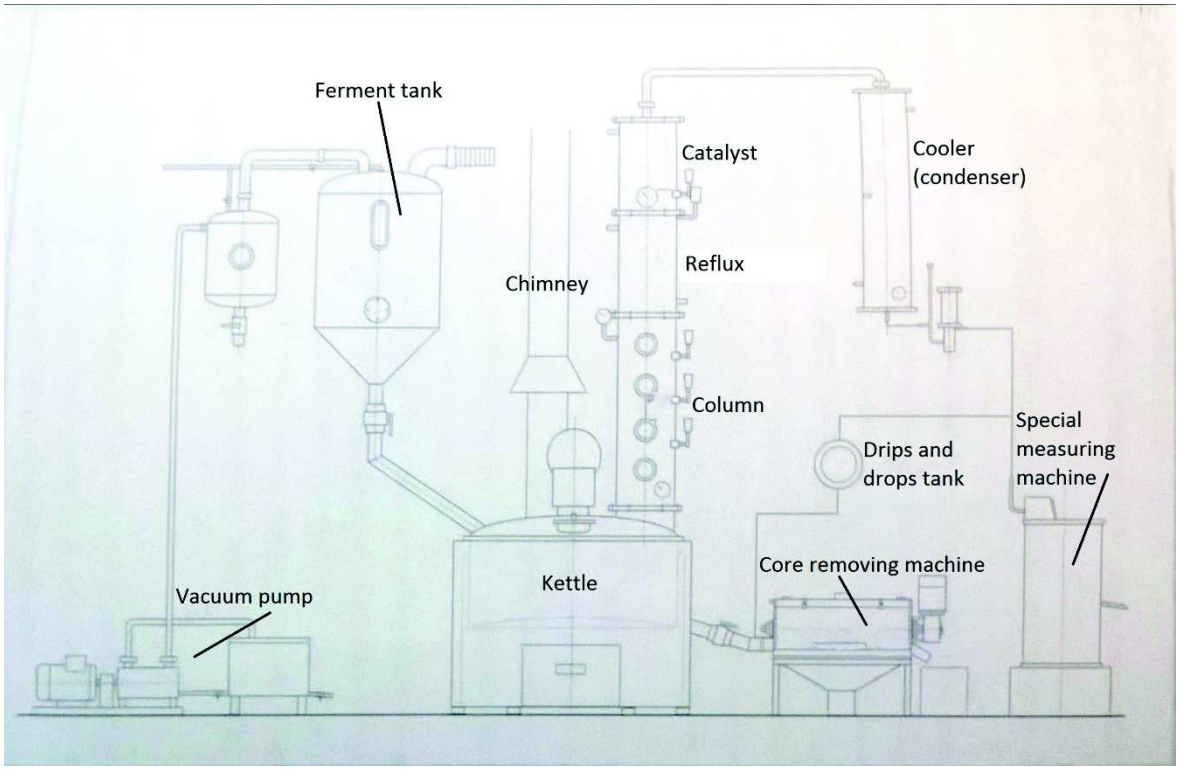
- Vacuum pump for ferment sucking,
- fermenting room,
- core removing machine,
- press,

- fruit crusher,
- three sumps (one for used ferment, one for swill and one for cooling water)
- drips and drops tank,
- cooling system,
- gas burner – kettle heating system.

Fermenting room can store up to 160 barrels with ferment, is heated by gas heating and is equipped with several vents designed to create airflow so the room does not fill up with carbon dioxide. Additional equipment is in form of fruit processing machines such as crusher and press.

Core removing machine is located outside the building and is used to remove cores from used ferment; it is directly connected to the kettle by a pipe, which is divided into two parts. One part goes to the core removing machine and can be switched to the second part which goes directly into the swill.

The technology is so called one kettle system with rectification column. Kettle is heated by gas burner. The kettle itself is made of stainless steel on the outside and from copper on the inside like the rest of technology. Technology is described on the picture below:



Distillery technology (Balaštík 2010) [edited by author], Figure 3

Every important aspect is described more in depth in the case study. Sufficient photo documentation is also included. The other type of technology “two kettle” system is described with its advantages and disadvantages in comparative analysis.

7 CASE STUDY

This case study is, as stated above, focused on small distillery in Moravskoslezský region. This establishment is quite popular in its area, which in this kind of business means that this distillery collects large amount of waste in the form distilled ferment, cooling water or fruit cores. This made it ideal target for case study.

In this chapter will be described the whole service providing process. The description will be focused on waste generation and disposal, in chronological order from fruit/ferment acceptance to waste removal from collecting container (sump) and ultimate disposal of it. The distillery is equipped with three sumps: the ferment sump, the swill sump and the water sump.

7.1 Customer types and serving

Since this case study targets one small distillery and its field of services in search for waste generation and describing its ways of waste disposal it is important to look at its customers the same way as the distillery does. Customers are the main source of waste, which distillery disposes of and are classified into three categories by distillery owner.

7.1.1 Ferment for distillation customer

First and most common type of customer is the one, who brings his fully fermented ferment for distillation. This customer is source of the least potential waste. In fact, waste that is generated by this customer is almost exclusively distilled ferment and cooling water, with exceptions when the ferment is faulty. If the ferment is faulty and the owner of distillery notices it he usually refuses to distil it and leaves it in the hands of the customer to dispose of it, but if the customer insists on distilling, then it leads to spirit drink, that is not suitable for drinking, but for distillery it is not a waste, since it is property of its customer.

Technically speaking used ferment is also property of customer, but in this case exists something as non-written rule between distillery and its customer, that the distillery will dispose of it. It is so, because it would be hard for owner to return the ferment from kettle to the customer, and also it is viewed as additional service of the distillery.

7.1.2 Ferment for safekeeping and distillation customer

This type of customer is the least occurring type of customer. This customer brings his already fermenting fruit to the distillery, where it is checked and either refused or accepted

for safekeeping. This safekeeping is done in fermenting room, which is specially equipped for storage of multiple ferments. The owner not only safeguards the ferment, but also treats it with special wine yeast and controls if it is still fermenting or if it is still healthy.

Because the ferment is physically present in the fermenting room, it is source of additional waste. This waste is mainly CO_2, which is produced by fermenting. There is also a risk that the ferment will become waste if it gets faulty, but that is only potential risk because this had happened according to owner only twice in eleven years of existence of this safekeeping service.

7.1.3 Fruit processing and distillation customer

This last type of customer is the most interesting for this case study, because he has the biggest potential of generating waste. It has higher potential then the other two types, because there is fruit processing, which is another waste generator. It highly depends on fruit processed into ferment. Plums for example are easily processed, since they are only washed and then put into plastic barrels and treated with wine yeast. Pears, apples or peaches are more demanding. Apples and pears need to be crushed (or juiced), while peaches need to be deprived of cores (Peach cores are sharp and can damage distilling technology).

7.2 Waste generation

It is important to state, that the start of waste generation in this small business is dependent on fruit type and preferences of customer. For example, there are some customers, which prefer fermenting only apple juice, instead of crushed apples. This means, that in this case there is waste in form of juiced crushed apples, which is undesirable and therefore waste.

Another important thing to state is, that not only type of fruit but also a period of time when the fruit is collected to be fermented, determines how much wasteful fruit there will be. If the fruit is mouldy, then it is extracted from the rest and is of no use, becoming waste. On the other hand, unripe fruit is also undesirable and is “thrown” away as waste.

In distillery subjected to case study, these two first types of waste are disposed of in two ways. First is related to juiced dried fruit and this mass of waste is thrown into compost pit, where it decomposes and is later used for fertilization of owners own orchard. The other type (unripe or mouldy fruit) is thrown into collecting container which is mainly for used ferment. Further disposal is described later in this chapter.

Each barrel of ferment can create its own volume of CO_2 in just one day, which would make fermenting room uninhabitable, but the room is designed for fermenting, so it has vents it its walls, ensuring constant airflow. Each barrel can also get bad, acidify or get any other fault described in Theory. In that case distillery (in both times this happened) poured bad ferment into ferment sump for later disposal along with used ferment.

Another waste generator is the distillation process itself. Chronologically the first is cooling water, which after heating itself over undesirable temperature (20°C in cooler or around 55°C in the reflux) is lead through pipes into one of the three collecting containers outside the building. Second comes drips and drops, which are collected in closed container in distillery, and after custom office employees measure its percentage it is then dumped into the ferment sump. Last is the ferment itself, which is either made from stone fruit like plums or other fruit like apples. Stone fruit is then sent through the pipe to the core removing machine (added in 2014) which splits cores and the rest of fruit mass send to the ferment sump. Fruit that does not have cores is sent through different pipe directly to the ferment sump. The owner said, that he bought the core removing machine, because biogas stations were refusing to take used ferment with cores.

The distillery always uses its own plastic barrels for fermenting. This brings also the need to clean them after the ferment is sucked into the kettle. The owner cleans the barrel after each use, so it would be available for another customer or to store it after the season ends. Cleaning itself generates additional waste. This waste is usually harmless and is used for watering plants or, if detergents were used, flushed into the swill sump. Usual composition of this waste is mostly water with ferment remains stuck in the barrel.

Heat is produced in huge amounts in distillery. It is mainly used for heating the ferment to the boiling point, but large amount of heat goes literally out through chimney. Some effort of recycling the heat is made and even planned for future date. The owner stated, that he plans use the residual heat for heating the fermenting room in winter. Some of the heat is absorbed by cooling water and is used for heating water in boiler since 2015. Secondary source of heat is the ferment itself. While fermenting the fruit generates heat. The heat from fermenting is of little consequence, but in a room with over 130 barrels of ferment can actually maintain temperature in the whole room, with only occasionally heating up with gas burners.

Other waste types like swill or dirty water from floor wiping are poured or flushed to the swill sump and later disposed of by third party. The owner pays regularly for disposal of the waste from two of his sumps (ferment sump and swill sump) to the agricultural company, which uses the waste for fertilizing or as biomass respectively.

7.3 Waste management in numbers

This subchapter is dedicated to quantitative approach to the case study where waste is shown in specific numbers. Data relating to amount of ferment from particular fruit are distorted by the fact, that statistics relating to fruit types fermented has been calculated on percentage of fruit types fermented in fermenting room.

In fermenting room was stored during the season 2014/2015 (season starts on 1st July and end on 31st June next year) 49360 l of ferment. In table below can be seen how much of different fruits was fermented and how much was it from total number. These percentages are used for further calculations on approximate volume of total ferment distilled.

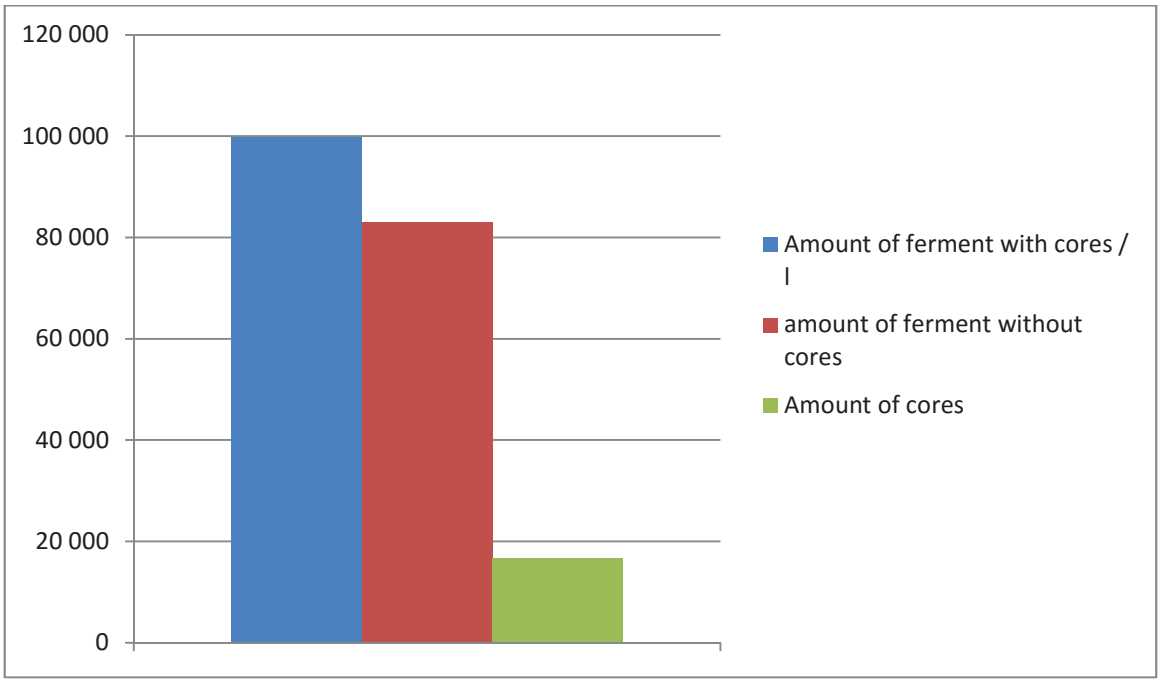
Ferment fruit representation, Table 1; Compiled by author

	Volume / l	% of total ferment volume
Cherry ferment	7 350	14.88
Plum ferment	14 515	29.41
Apricot ferment	1 800	3.65
Mirabelle ferment	3 120	6.32
Pear ferment	3 025	6.13
Apple ferment	13 130	26.6
Other fruit ferments	6 420	13.01

From the table above can be read that around 54 % of all ferment is from core fruit. But for the next calculation total volume of ferment stored in fermenting room is used. The calculation focuses on CO_2 emissions.

One ton of CO_2 equals 556.2 m^3 of CO_2. In studied distillery was stored 49360 l of ferment throughout the season and during the stormy fermentation the ferment creates approximately its own volume in CO_2. This results in 641.68 m3 or 1.15 t of CO2.

Cores are removed from ferment after distillation and according to owner there is around 50 l of cores per 300 l of ferment. The graph below shows proportion of cores to ferment and how much it helps in waste management aside from that the biogas station refuses to take ferment with cores. Cores in ferments from core fruit take around 16.7 % of their total volume.



Core removing proficiency, Figure 4

The distillery produced 9065.68 l of pure alcohol in 2014/2015 season. Given the average amount of pure alcohol per one full kettle is calculated amount of full kettles and from that amount of processed ferment in that season. Average amount of pure alcohol from full kettle was in that season 14.8 l which after calculation says that there were 612,55 full kettles of ferment. With kettles maximum volume 300 l the final amount of ferment processed in that season is 183 765 l. Next table shows how much of this ferment is dumped into the sump.

Dumped ferment, Table 2; Compiled by author

	Ferment / l	Distilled alcohol (average 61.34 %)	Removed cores / l	Ferment dumped into the sump / l
Drupe (Core fruit)	99 711.43	7 980.88	16 618.57 (16.66 %)	75 111.98
Coreless fruit	84 053.57	6 798.52	0.00	77 255.05
All	183 765	14 779.4	16 618.57 (9.04 %)	152 367.03

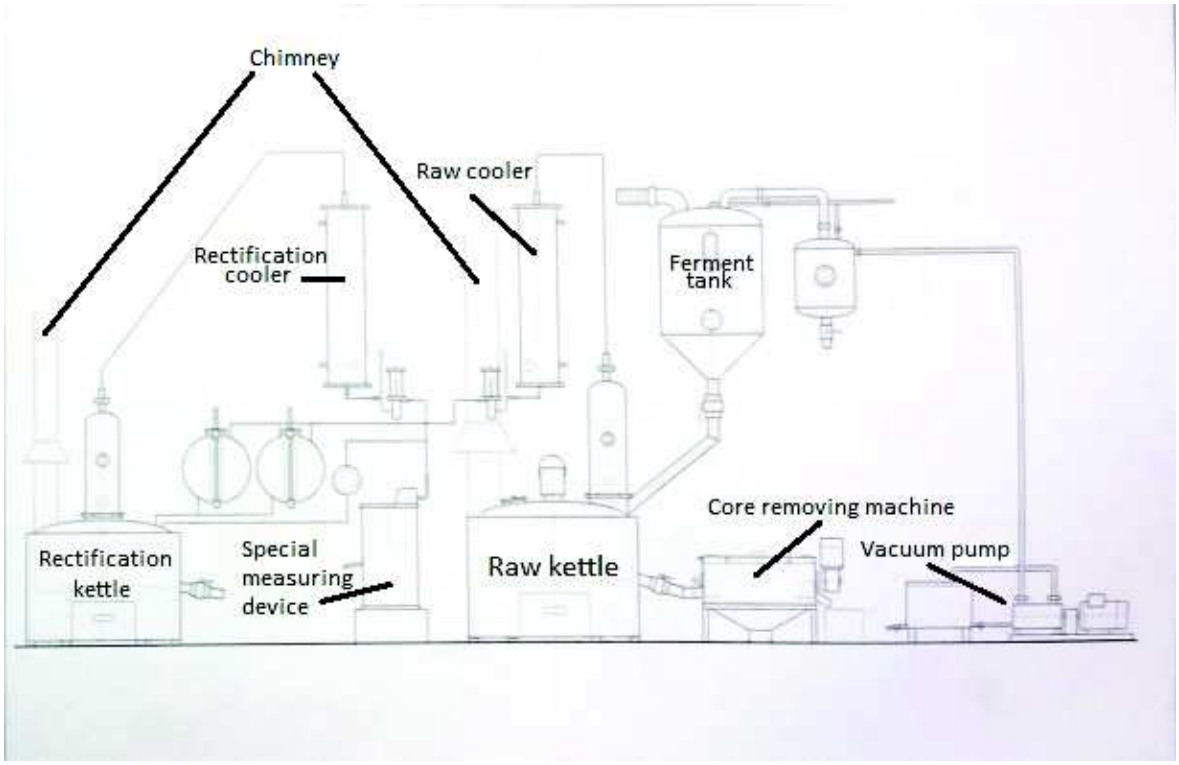
The ferment sump has the capacity of 10 000 l, and in the observed season was emptied sixteen times. Swill sump has the capacity of 4000 l and has been emptied four times during that season. Last sump that has to be emptied is water sump. It was stated that water is used for watering the owner's orchard, but a lot of water is needed to be disposed of by other means. The water sump has the capacity of 9000 l and during the season is emptied by third party twelve times (during distillation of each kettle is used in average 284 l of water, resulting in 173 964.2 l of water during observed season). Every sump emptying by third party, costs the owner 1 500 Kč. This results in 48 000 Kč in waste management cost for season.

8 COMPARATIVE ANALYSIS

This chapter revolves around several chosen distilleries (including the one in case study). Several things will be then compared, such as equipment, distillery technology, waste management methods, financial expenses for waste management amount of pure ethanol distilled and so on.

There are some differences between certain distilleries; most of them are in their equipment. The distilleries function on different technologies, some are one kettle technologies that were described in chapter six and other are two kettle technologies, which are described on following lines.

Two-kettle system differs from the one-kettle in several ways. The most significant is that the one kettle uses only one kettle for distilling and makes additional distillations thanks to the rectification column, the two-kettle system heats the ferment and the product of distillation collects in the second kettle (rectification kettle) after it cools down in cooler (first distillation). Rectification kettle is then used for second distillation again to achieve high quality spirit drink (second distillation). It is obvious that these two technologies are named after the numbers of physical kettles it uses. Below is shown picture depicting two-kettle system:



Two-kettle distillery technology (Balaštík 2010) [edited by author], Figure 5

8.1 Distillery comparison

Six distilleries were chosen for comparison, the distilleries are of various size and age. The first thing that is compared is their equipment, technology and form of fuel they run on. Since none all of the distillery owners wanted to by anonymised, the distilleries are labelled with letters A, B, C, D, E, F. This comparison is focused mainly on chosen distilleries; many more distilleries with different equipment and waste management approach exist.

Equipment comparison, Table 3; Compiled by author

Distillery	Equipment	Technology	Fuel
A	Vacuum pump, drips and drops tank, ash pan, ash container, 24 000 l sump	Two-kettle (250 l)	Wood
B	Vacuum pump, drips and drops tank, 3 sumps (10 000 l, 4 000 l, 9 000 l), core remover, fruit crusher, press, fermenting room	One-kettle (300 l)	Natural gas
C	Vacuum pump, drips and drops tank, 6 000 l sump, core remover, fruit crusher	One-kettle (300 l)	Natural gas
D	Vacuum pump, drips and drops tank, 2 sumps 12 000 l, core remover	Two-kettle (150 l)	Natural gas
E	2 Sumps (12 000 l, 6000 l) drips and drops tank, ash pan, 6 ashbins, overflow water tank, stream water cooling system	Two-kettle (600 l)	Wood
F	3 Sumps (8 000 l, 4 500 l, 7 000 l), fruit crusher, ash pan, ash container, fermenting room	Two-kettle (300 l)	Coal

From the table above, can be seen the differences in distilleries. It is obvious, that fuel also affects amount of waste. Ash container or ash bins need to be regularly emptied. Distillery E gives its ash for free to anyone who wants. People use it for enhancing their garden soils with minerals. Distilleries A and F have regular buyers for ash.

Sumps with ferment are in these distilleries disposed of similarly. Each distillery has in its vicinity agricultural company which uses it either as fertilizer (after powdering it with lime) or as a biomass source in biogas stations.

In water management there are more differences then just the size of water sumps. For example distillery B uses heated water from reflux for heating water in boiler. Distillery E takes water from nearby stream and after this water is heated it is forwarded to overflow water tank where it partially cools itself before overflowing back to stream. This could cause problem for stream ecosystem, because it heats the stream water mainly in winter.

All distilleries except for distillery F own drips and drops tank, which has been their standard equipment in recent years. The owner of distillery F refused to talk about his way of drips and drops disposal. However customs office in this region is tasked with measuring drips and drops, which means there might be some agreement.

Another table shows the correlation between amount of pure alcohol distilled and amount of ferment (number of full kettles). Distillery B lost its data on season 2013/2014 and distillery D was opened in season 2014/2015.

Amount of pure alcohol distilled in last two seasons, Table 4; Compiled by author

Distillery	l of 100% alcohol 2013/2014	l of 100% alcohol 2014/2015
A	6 354 (11.9 per kettle)	7 284 (12.1 per kettle)
B	N/A	9 065.68 (14.8 per kettle)
C	4 983.1 (14.3 per kettle)	4 821.3 (13.6 per kettle)
D	N/A	1 536.83 (7.6 per kettle)
E	10 453.43 (27.4 per kettle)	12 003.81 (28.7 per kettle)
F	5 349.2 (14.5 per kettle)	5 491.5 (14.2 per kettle)

Next table shows amounts of ferment distilled in individual distilleries and amount of cores removed if the distillery owns a core-removing machine. These amounts are tied to final waste management expenses for each distillery, provided by their respective owners.

Ferment and core removed amounts, Table 5; Compiled by author

Distillery	l of ferment 2013/2014	l of ferment 2014/2015	Cores removed 2013/2014	Cores removed 2014/2015
A	133 487	150 495	N/A	N/A
B	N/A	183 763	N/A	16 618.57 l
C	104 541	106 352	9 413.51 l	9 571.7 l
D	N/A	30 332	N/A	2 729.9 l
E	228 907	250 951	N/A	N/A
F	110 673	116 017	N/A	N/A

Distillery A claims to spend 35 000 Kč for waste disposal, but plans to purchase core remover to further minimize amount of unusable waste produced. It is obvious, that distillery E pays for its waste management the most, but thanks to its different source of cooling water it is no much higher than distillery B's. Owner of distillery E stated that he pays around 50 000 Kč annually for waste disposal, but also stated that he will not invest any more money into waste minimization. B pays annually 48 000 Kč for waste disposal, but is open for any possible way of reducing waste. Owner of distillery B plans to buy chimney heat exchanger to put waste heat to use. C claims to pay surprisingly high amount of money in comparison to others and that is 65 000 Kč per year. As for distillery D, this is a new distillery with low waste generation and the owner calculated his expenses to 14 000 Kč. The last one claimed that he uses all of his ferment on his garden, which is hardly believable or very environmentally unfriendly. Despite that, the expenses for waste disposal were said to be around 6 000 Kč.

9 SUGGESTIONS

Even though every distillery has its own way of waste disposal or respectively re-usage, all of them could improve their ways. In this chapter some suggestions for such improvements are described. All of those suggestions are targeted on heat,, ferment, water, cores and drips and drops. Only suggestions of methods that were not found in any distillery are proposed.

9.1 Heat

Heat is very useful tool, which can be used in many ways. One of those ways is to design a water-flow from cooling system, which would be warming up greenhouse in winter, while cooling down this water to be reused in cooling system. It could be done as closed circuit. This solution requires pipes to transport the water into the greenhouse and back. There is however a problem with the possibility of water freezing inside of those pipes (main part of season is in winter), when the distillery is not running non-stop. This could be solved by guiding the pipes deeper under the surface, but this also brings lower temperature exchange and the water might not be effectively cooled down for further reuse.

Another possibility of using heat from distillery, this time the heat that goes away through chimney could be used as house heating system. For this heat exchanger would have to be installed on the chimney and the heat transferred in some form to the required place (would be best if the distillery would be in desired building). The mean of transfer could be water or heating oil. If the distillery also owns a core remover, the excess heat might be used for quicker drying of the cores.

9.2 Ferment, cores and drips and drops

The ferment is already being used in biogas stations, but it could also be used for composting. There are however large amounts of ferment in individual distilleries so it would have to be distributed to several composts.

The cores, which are used as mulch, hard fuel or as filling for heating pads, could be crushed and mixed with sawdust from sawmills. This mixture could be then pressed into a briquette. These briquettes would be more heat efficient depending on how big portion would the cores make.

Drips and drops is a side product, which is usually disposed of with the ferment. There might be an actual use for it. It is not a suggestion, because some distilleries are already doing this. Drips and drops could be sold to large industrial distilleries. Industrial distilleries are using fractional distillation for extraction of specific substances like amyl alcohol or isopropanol.

CONCLUSION

This thesis revolved around waste management systems in several distilleries and around suggestions for minimizing their amount. Case study was in place, because it was able to describe the whole process of waste generation and waste management in chosen distillery in detail and therefore depict the whole picture of the distillery waste management.

The case study focused on waste management in small distillery and mainly on describing the waste generation and waste management execution. While this distillery could improve some of its ways, it is obvious, that the owner slowly improves the imperfections in his system to minimize the amount of physical waste or even the waste in form of heat. Some of the suggestions are in fact from an interview with this distillery owner.

In the long run, waste minimization should be beneficial not only to the owner but to the environment as well. The environment and more importantly nature provides this kind of establishment with fruit and therefore with their job. It is only logical, that owners or their employees should care about protecting environment and not intoxicating it.

But ultimately, it is not cheap to keep minimizing the amount of waste. The more effective minimization the more expensive and time consuming for maintenance it becomes. This is why many owners of these small distilleries settle for cheap and undemanding forms of waste management although they might not be very nature friendly.

The comparative analysis was chosen to compare the distilleries between each other and to explain that every distillery has its own ways. Also to comparison of distilleries allows for looking at the problem from bigger perspective. Some of the suggestions were made thanks to this larger perspective. Ultimately goals of this paper were fully achieved.

It would be much better if this topic was more highlighted and handled by more authors and specialists. Other works could be focused on individual waste types and their further use or specific waste management methods.

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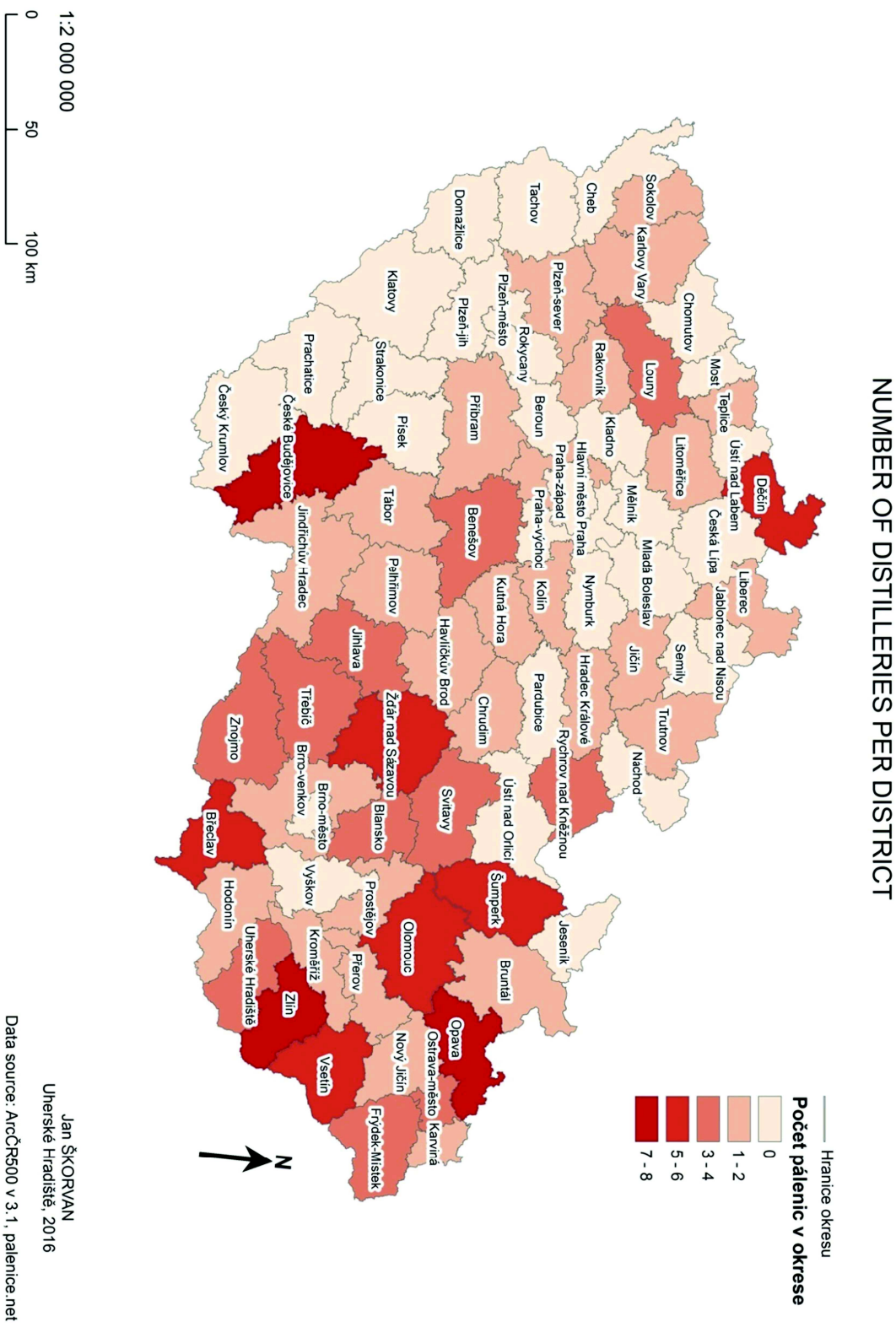
LIST OF FIGURES

LIST OF TABLES

APPENDICES

APPENDIX P I: NUMBER OF DISTILLERIES IN INDIVIDUAL DISCTRICTS; [SOURCE: AUTHOR]



Numbers of distilleries in individual districts ,Appendix 1

APPENDIX P II: INTERVIEW TRANSCRIPT; [SOURCE: AUTHOR]

I: What makes a distillery different from other establishments of this type?

S: In the terms of technology it is mainly the size of it. Also the production process is the same in general; however there are many types of distilleries mainly different because of the material they use for spirit drink or respectively alcohol production. Also the rest of the distillery types own the distillate after the distillation is complete and then sell it. In the type of distillery we are talking here, only a service of distilling is sold.

I: Do distilleries have a free hand in their undertaking or do they have to report to some higher authority?

S: All the distilleries fall under the jurisdiction of the Customs office and have to report on how much of the spirit drinks was created and how much individual customers had distilled. This is because there is half of the consumer tax on spirit drinks in these type of establishments. And every customer only can have in one season 30 litres of 100% alcohol which translates into roughly 60 litres of 50% alcohol.

I: What about people that distil their own spirit drinks at home?

S: There is no way of knowing how many of these people are there, but i tis actually very common for my customers to claim, that it is legal to distil spirit drinks at home, if it is only for them. That is not truth, it is basically tax cutting and therefore illegal. These people also very often do not remove drips and drops from the core spirit drink and it is dangerous for health, because in these parts of the drink are higher amounts of methanol and other substances bad for human health. But I would say that the amount of black distilleries slowly recedes, because there is around six hundred legal distilleries in the Czech Republic at the moment and the number grows every year.

I: Why is there so many small distilleries in the Czech Republic?

S: It is seen as profitable business plan, and people like drinking.

I: What about your own distillery, what equipment does it have?

S: Well, in my distillery i can boast with Vacuum Pump for ferment sucking, core removing machine, press, fruit crusher, gas burner, drips and drops tank, three sumps where one is for processed ferment, one for swill and the last one for water from cooling system. I

usually use this water for watering my orchard. I also have different types of customers depending on if they use my service of ferment safeguarding in fermenting room.

I: So you sort the customers into some categories?

S: Actually into three types. One is a customer that comes to me only for distillation, another one comes with his ferment and asks me for safeguarding and the last one brings his fruit to me and i am to create the ferment and safeguard it.

I: What about waste generation where does it all start?

S: Technically under the tree, but in my distillery it starts with me accepting fruit from the customer. I have to sort it and throw away moulded fruit to increase the quality of the ferment and in therefore the spirit drink itself. Also the ferment can turn bad and then it is a waste to me, this however happened once in the ten seasons. During the fermentation a lot of CO2 is produced and the rest of the waste generation i can show you in praxis.

I: Could you provide mi with numbers on your waste management, such as total volume of ferment you distilled or stored throughout the season?

S: Of course i can, I will give you my personal statistics and some other data if you need it.

I = Interviewer

S = Mr. Škorvan

The interview was carried out in Czech language, but as the entire thesis is written in English this transcript was also translated.

Interview Transcript, Appendix 2

APPENDIX P III: SUMPS; [SOURCE: AUTHOR]

Sumps, Appendix 3

APPENDIX P IV: FERMENTING ROOM WITH PLASTIC BARRELS; [SOURCE: AUTHOR]

Fermenting room with plastic barrels, Appendix 4

APPENDIX P V: DRIPS AND DROPS COLLECTING TANK; [SOURCE: AUTHOR]

Drips and drops collecting tank, Appendix 5

APPENDIX P VI: PIPE LEADING TO THE CORE-REMOVER OR SUMP; [SOURCE: AUTHOR]

Pipe leading to the core-remover or sump, Appendix 6

APPENDIX P VII: CORE-REMOVER; [SOURCE: AUTHOR]

Core remover, Appendix 7

APPENDIX P VIII: BOILER HEATED WITH COOLING WATER; [SOURCE: AUTHOR]

Boiler heated with cooling water, Appendix 8

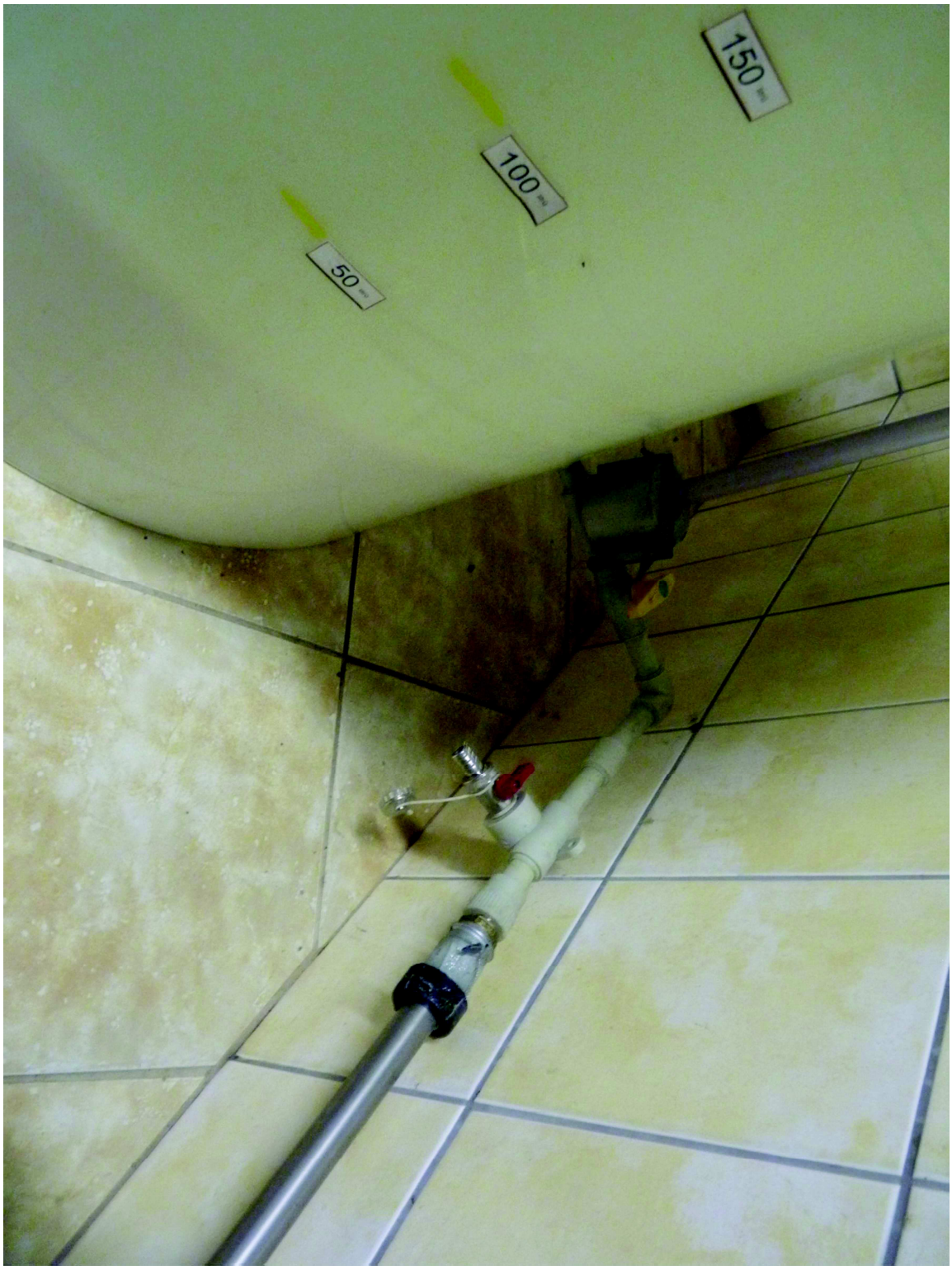
APPENDIX P IX: RECTIFICATION COLUMN; [SOURCE: AUTHOR]

Rectification column, Appendix 9

APPENDIX P X: FERMENT IN A BARREL; [SOURCE: AUTHOR]

Ferment in a barrel, Appendix 10

APPENDIX P XI: PIPELINE LEADING FROM DRIPS AND DROPS TANK TO THE SUMP; [SOURCE: AUTHOR]



Pipeline leading from drips and drops tank to the sump, Appendix 11

APPENDIX P XII: CHIMNEY; [SOURCE: AUTHOR]

Chimney, Appendix 12