"From Trash to Treasure: Converting Organic Waste into Bioethanol"

Arden Setiawan[1] Clarke Dharya Sunarto [2] Patrick Eugene Widjaja [3]
[1,2,3] SMP Kolese Kanisius

Abstract

Air pollution has become a very troubling problem in recent years. Even Indonesia has occupied the 9th position as the city with the highest pollution level in the world. High air pollution causes various serious problems, one of which is health problems. The cause of high air pollution is caused by many things, but the highest cause is motorized vehicles. Motorized vehicles that are widely circulating in the environment today are motorized vehicles that use fuels that are not environmentally friendly, resulting in air pollution. In addition, the fuel used is a non-renewable fuel so there will be a time when resources will run out. One solution that can be used to solve this problem is to use bioethanol. Bioethanol can replace current engine fuels by being more environmentally friendly and using renewable resources. In this research, we design a bioethanol production machine from organic waste. This machine aims to reduce air pollution and reduce the amount of organic waste that is present every day. This machine will perform several bioethanol production processes from organic waste, such as fruits, vegetables, fruit meat, and rice. This process has several stages, in our design there are five stages, namely: food sorting, liquification, saccharification, fermentation, and distillation. In our research, we can reduce air emissions by 2% by using bioethanol.

Keyword : *Air Pollution, fuels, design machine*

INTRODUCTION

Air pollution is one of the major environmental problems, especially for urban ecosystems with large populations. Public unrest is growing as air quality deteriorates all the time. The presence of air pollution is closely related to health decline, including chronic obstructive pulmonary disease (COPD), acute lower respiratory disease (ALRI), cerebrovascular disease (CEV), coronary heart disease (CHD), lung cancer (LC) tuberculosis, and other respiratory diseases [1]. In 2019, the Global Burden of Disease (GBD) estimated that air pollution caused 5054 deaths (or 54 per 100,000 people) [2].

The biggest contributor to air pollution in densely populated cities is the use of a large number of motorized vehicles. For example, in the DKI Jakarta area, as reported by [3] the number of active motorized vehicles increased by 5% from 2018 to 2022. The increase in motorized vehicles every year will certainly

cause an increase in air pollution in Jakarta. Based on the guidelines of the World Health Organization, one of the factors for assessing the level of air pollution can be seen from the content of toxic gases released into the atmosphere such as particulates (PM2.5), CO2, CO, SO2, NOX, and PM10. Based on IQ AIR data [4] it can be concluded that the quality of air pollution in Indonesia is very high. Indonesia ranks 14th most polluted country in the world with an average PM 2.5 of 37.1 which exceeds 7 times to 10 times the WHO guidelines. In addition, Jakarta as the capital city of Indonesia is also the 9th most polluted city in the world.

The source of harmful gases in the air today comes from the combustion of fossil fuels used by motorized vehicles. Pertalite is the mainstay fuel for the people of Indonesia, where pertalite consumption continues to increase every year. It can be seen that the increase in pertalite consumption in Indonesia has increased by an average of around 5 million each year [5]. Pertalite fuel is the type of fuel that produces the highest C02 exhaust gas. With these two data, it can be said that the motor vehicle fuel used by the Indonesian people is not environmentally friendly [6]

In addition, the fuel we use daily comes from petroleum and coal. Both natural resources are non-renewable so that one day, the supply of both natural resources will run out. If both natural resources run out, it is certain that human life will be chaotic. In reality, the level of public demand for motorized vehicles is still high [7].

Bioethanol is one of the alternative solutions to reduce dependence on fossil fuels whose existence is increasingly depleting and bioethanol can also reduce harmful vehicle exhaust emissions. Bioethanol is an alcohol compound obtained through the fermentation process of biomass (sugary materials, starchy materials and lignocellulosic materials) with the help of microorganisms. Bioethanol can be a substitute for gasoline fuel which is not environmentally friendly. The utilization of bioethanol as fuel can be through blending with fossil fuel (gasoline) or used directly in 100% composition for certain uses. Bioethanol provides more environmentally friendly exhaust emissions [8].

Based on research conducted by Asril et al., (2014) on the effect of the use of e-10 bioethanol fuel on the content of CO and HC gases on Yamaha Jupiter MX motorcycles, it shows the difference in CO and HC gas content on premium fuel and E10 bioethanol produced by vehicle engines. the use of E-10 bioethanol fuel can affect exhaust emission levels with a decrease in exhaust emission levels by 1-2%. This is due to the OH molecule contained in the ethanol molecular arrangement so that it can react with CO gas and neutralize the exhaust gas released [8].

The development of bioethanol in Indonesia is currently quite a concern. lately, a lot of research

has been done on the manufacture of bioethanol from various biomass raw materials both on a laboratory and industrial scale. One of them is organic waste in the form of food waste derived from plants in the form of leftover rice, fruit peel waste and vegetable waste. All types of waste are part of plants that contain sugary materials, starchy materials and cellulosic materials. So that all these materials can be processed into bioethanol through the fermentation process and produce side compounds in the form of ethanol compounds [9].

Several studies have been conducted to process organic waste into bioethanol, Whitaker also explains in his book that substrates that can be fermented to become alcohol are: Materials containing sugar, including research conducted by Yonas, et al., (2013) concluded that from a stalk of corn, the ethanol content produced by fermentation for three days was 5.34%, and on the fifth day and seventh day had an ethanol content of 3.2% [10].

Research conducted by Yadi, et al., (2021) showed that the dregs produced in the process of making bioethanol from leftover fruit can be used as organic fertilizer, another study from Atiqah, et al., (2014) showed that tomato fruit waste can also be used for bioethanol production. Then research conducted by Hendrasarie and Mahendra (2020) showed that 100 grams of vegetable leftovers such as carrots, cassava, cabbage, potatoes, and mustard greens can produce different ethanol levels, carrots have the highest percentage of 7%. 11% cassava, 7% cabbage, 13% potatoes, and 8% mustard greens [11,12,13].

Organic waste processing in Indonesia is still very minimal. Various efforts to sort waste still often fail to be realized. The source of organic waste itself comes from many places, including leftover sales in traditional markets. The number of traditional markets in Indonesia reaches 16,235 where the waste produced reaches 2,723,655.20 tons / year [15].

Organic waste management in traditional markets is a challenge in itself. However, in many cases, the problem of waste management, including organic waste, is still an issue in traditional markets, with most of the waste that may end up in landfills being unmanaged or even illegally dumped and causing a buildup of waste that eventually results in foul odors or sources of disease, not infrequently also waste is dumped into the sewer flow which eventually causes blockage of the flow and results in flooding [15].

Indonesia is the largest food waste disposal country in Asia. The University of Nations Environment Program (UNEP) total food waste in Indonesia is 20.93 per year (2021). From 2000-2019, Indonesia reached 23-48 million tons/year [16]. Based on an article that has been published, the food waste generated by Restaurant "X" Surabaya is above the normal limit (41%) with an average of 5,621 kg of organic waste per day or 48.77% of the total waste

generated [17]. Indonesia has more total food waste than all countries in ASEAN and almost has all food waste in ASEAN combined [16].

Based on the statement previously described, this research aims to study and design the process of making bioethanol from organic waste. This design can be a solution to 2 existing environmental problems, namely air pollution and the accumulation of organic waste. Therefore, with this research we really hope that the results of this research can be useful for people's lives.

Methods

Planning

1. Research about current environment situation
2. Research about air pollution and yearly fuel consumption
3. Research about the way to create an alternative solution for fuel

Conceptual Design

1. Think about what processes need to be done and how the machine will work
2. Think about the flow of the transformation process
3. Sketch the design

Detailed Design

1. This design use 5 stages, separating the trash, liquefaction, scarification, fermentation, and distillation
2. Think about the material going to be used for each stage
3. Calculate the economy aspect

Evaluation of the design

1. Think about the processing flow from organic trash to usable bioethanol fuel
2. Provide an overview of the advantages of the design compared to other designs

Results and Discussion

A. Flow design drawing of bioethanol making machine from organic waste

In general, the flow of making bioethanol from organic waste is divided into 5 stages, namely food sorting, and then liquification, after that saccharification, fermentation, and distillation

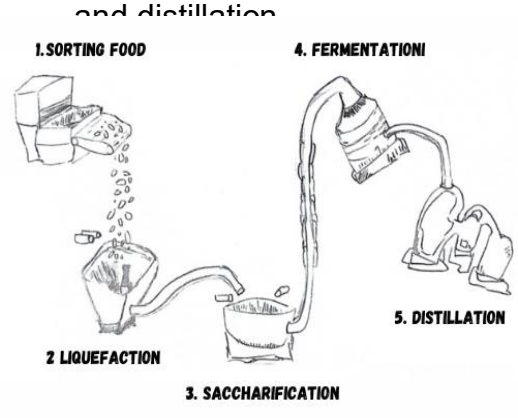

Figure 1. Overall design of the process of processing organic waste into bioethanol

B. Design description of each step on the bioethanol making machine from organic waste

1. Sorting Food

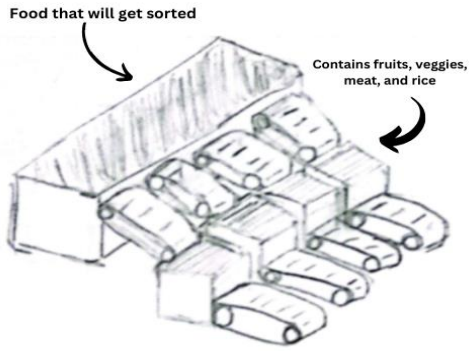

Figure 2. Design of organic waste food sorting process

In the sorting food stage, waste is sorted manually with human hands with the help of tools. The selection is done manually so that the selection can be done perfectly and it can also provide new jobs for the community.

Waste is sorted into 4 groups, namely fruit peels, vegetables, fruit meat and rice. In our design, each waste will be on a different conveyor depending on the type of waste, namely fruits, vegetables, meat, and rice. the source of waste used is not rotten waste but fresh waste.

For this reason, the waste that will be processed is fresh waste that we get from traditional markets and restaurants. Waste that has been sorted will be collected in different storage. After that, each type of waste will be weighed to determine the percentage of enzymes and yeast that must be used. Each type of waste will be processed with the same process [18].

2. Liquefaction

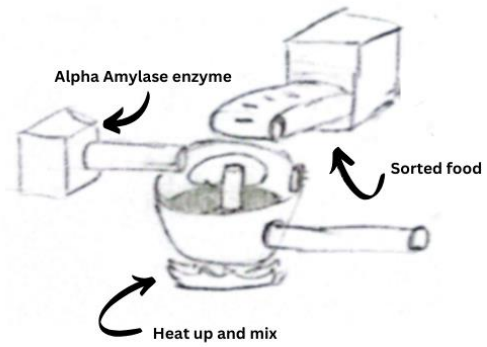

Figure 3. Design of liquefaction process

At this stage the food waste that has been sorted will be moved and the stirring process is carried out until it is crushed and well mixed. Liquefaction is a process of heating at 95 degrees Celsius [20] and stirring which aims to convert starch/starch in food waste into complex sugars with the help of the Alpha Amylase enzyme of 0.03% of the total amount of raw materials.

The alpha amylase enzyme works to chemically break the starch structure into complex sugars. The completion of the Liquification process is characterized by the parameters of the processed slurry turning into a more liquid like soup. In this process, food waste will gelatinize and convert into complex sugars (dextrin) [18].

3. Saccharification

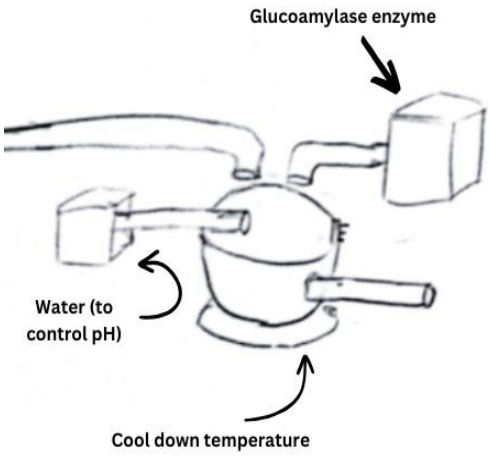

Figure 4. Saccharification process design

The next stage is the saccharification stage. At this stage the complex sugar (dextrin) that has been produced in the liquification process will be converted into simple sugar (glucose). In the saccharification stage, the complex sugar (dextrin) will be converted into glucose and some fructose with sugar content ranging from 5 to 12 percent and then will be cooled to a temperature of approximately 37 degrees Celsius. The cooling process is carried out so that the glucose molecules are not damaged. The cooling process is carried out using a cooling water system, namely by using cooled water [18].

In addition to regulating temperature, in this process the pH value (acidity) must also be adjusted so that changes in the composition of complex sugars to simple sugars are achieved. Therefore, at this stage there is a pH control that aims to control the pH value of the sugar product to be processed [18,19].

4. Fermentation

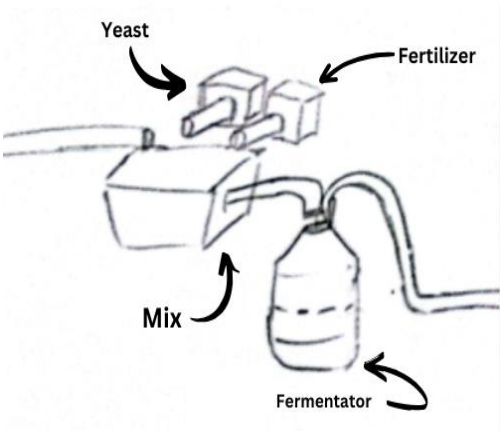

Figure 5. Design of fermentation process

Fermentation is the process of converting glucose into ethanol with the help of yeast microorganisms. It takes time for yeast to convert glucose into ethanol so that the saccharification and fermentation process takes 3, 5, 7, to 9 days [18,19].

Based on research conducted by Meldha et al. (2012), the best fermentation time is in the range of 48 hours. Then added urea fertilizer as much as 0.14 percent and NPK fertilizer 0.02 percent of the total amount of raw materials (for the growth of yeast cells) [20].

The fermentation process occurs under anaerobic conditions. Therefore, in our design, the fermenter is tightly closed with the aim that no oxygen enters so that microorganisms can ferment perfectly [19].

5. Distillation

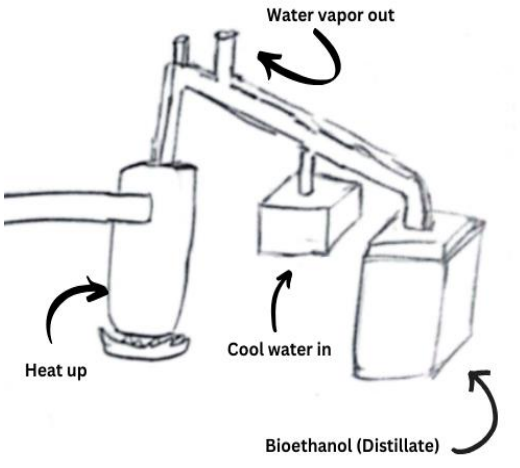

Figure 6. Distillation process design

Finally, in the distillation stage at 78 degrees Celsius, ethanol will evaporate before water which has a boiling point of 95 degrees Celsius. The ethanol vapor in the distillator will flow into the condenser so that it is condensed into ethanol liquid. [18].

C. Review of the economic aspects of processing organic waste into bioethanol

Based on research conducted by Hendrasarie and Mahendra in Wonokromo, they obtained 500 kg of food waste in the form of fruits and vegetables, from 600 kg of organic waste, this study used 600 grams each to be utilized into bioethanol. Then in 100 grams of vegetables, on average produce 15-20 ml of bioethanol, so 500 kilograms of vegetables can produce 75-100 liters of bioethanol [13].

The current market price of bioethanol ranges from Rp 12,000 to Rp 15,000 [20]. From this price range, the income from making bioethanol from waste can be calculated. In 100 grams of waste, about 15 - 20 ml of bioethanol is obtained. So, on 1 kg of waste, about 150 - 200 ml of bioethanol is obtained. If it is considered that the price of bioethanol per liter is IDR 15,000, then the price of 200ml of bioethanol will be at IDR 3,000. From the calculation, it can be concluded that the income will amount to around Rp 3,000,000 from every 1 ton of waste processed.

The market price of pertalite Rp.10,000 compared to the price of bioethanol Rp. 15,000 also bioethanol reduces gas emissions by 2%. From the price comparison it can be concluded that with a price increase of 50% of the price of pertalite, bioethanol can reduce gas emissions by 2%. Until we can reduce gas emissions by 2% with a 50% price increase, therefore bioethanol is more environmentally friendly.

D. Advantages of processing organic waste into bioethanol

By processing food waste into bioethanol, the air pollution that occurs in Indonesia, more specifically Jakarta, will drop dramatically. We know that Jakarta Indonesia is one of the most polluted cities in all of Indonesia and its citizens have to suffer because of it. If only a small percentage is put into gasoline, it can also reduce air pollution which is a big problem for the people of Indonesia. Organic waste, which has become a problem in the community where piles of garbage have no place to be dumped, can be processed into more useful items which can also help the surrounding environment and the air we breathe directly.

In addition, we can also be more efficient in our gasoline payments with the use of bioethanol, as the process has been explained earlier, the manufacture of bioethanol is arguably quite easy, so that Indonesian people can also be helped in saving money and other materials.

Conclusion

Bioethanol production from organic waste can be a solution to 2 environmental problems, namely air pollution and the accumulation of organic waste. The design of bioethanol production machine from organic waste consists of 5 stages, namely waste sorting, liquification (heating and crushing of materials), saccharification (conversion to glucose/sugar), fermentation (mixing with yeast & other microorganisms), and distillation (separation of substances). 150-200 ml of bioethanol is obtained from every 1 kg of processed waste. The market price of bioethanol ranges from Rp. 12,000 to Rp. 15,000. Based on these data, it can be calculated the income obtained from each processed waste, which is Rp. 3,000 per 1 kg of processed waste, up to Rp. 3,000,000 (3 million rupiah) per 1 ton of processed waste.

Acknowledgments

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