Utilization of plastic waste processing for oil fuel at Tambaan Beach, Pasuruan City

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Abstract. The amount of waste in Indonesia is estimated to reach 68 million tons in 2019, of which 9.52 million tons is a plastic waste. With this amount, Indonesia is ranked second in the world as the largest producer of plastic waste. One area that suffers from plastic waste is the coastal area. This plastic waste is difficult to decompose and cause environmental problems. Likewise, it happened on the Tambaan coast in Tambaan sub-district, Panggungrejo subdistrict, Pasuruan city. Currently, accumulation of plastic waste is evident throughout the coastal area. The accumulation of scattered plastic waste and its proximity to the residents' settlements has become a hotbed of mosquitoes and caused a pungent smell. The Serving Doctoral Program at Universitas Brawijaya offers a solution to process plastic waste into fuel oil such as diesel, kerosene, and premium. The technology used was Muryani's distillation from Wlingi, Blitar Regency. The technology can change certain types of plastic waste to produce fuel. Karangtaruna Bina Hang Tuah was acted as a reliable partner to assist the implementation of the technology on site. This study aims to strengthen the capacity of Karangtaruna in Tambaan Village to be more concerned about the environmental problems of Tambaan beach by processing waste that has been polluted by plastic waste. The results of plastic waste treatment showed that 10 kg of dried plastic waste can be transformed into diesel, premium and kerosene with the efficiency value of 60%, 35%, and 15%, respectively.

1. Introduction
Plastic waste in Indonesia currently amounts to 64 million tons/year of which 3.2 million tons/year discharged to the sea. Indonesia is the second-largest contributor of plastic waste in the world. The data shows that China is number one largest contributor in the world with 8.81 million metric tons per year, Indonesia contributes 3.21 million metric tons per year, the Philippines accounts for 1.88 million metric tons per year, Vietnam accounts for 1.82 million metric tons per year, and Sri Lanka accounts for 1.59 million metric tons per year. The waste is a subjective notion [1]. Some see waste as a risk to public health and the environment, some see it as a mere aesthetic inconvenience, and others see it as a
source of income. In the informal recycling sector, there is no question that waste is perceived as a resource. Thinking about processing plastic waste to become economically valuable goods is carried out in various ways, one of which is by making a garbage bank. However, some manage waste by submitting it to the informal sector such as scavengers. The solid waste management (SWM) usually consists of both the formal and informal sectors [2]. In Indonesia, the formal sector consists of municipal agencies whereas the informal sector consists of unregistered, unregulated individuals, groups, or small businesses.

In solid waste activities, the informal sector refers to recycling activities that are conducted by scavengers, itinerant waste pickers, or itinerant waste buyers. Improved efficiency in the waste collection may lead to unemployment of scavengers and waste pickers who belong to the poor strata of society, whereas issues on inclusive society force municipalities to fight against social exclusion. The normative theory of social exclusion and the concept of capital forms were used to address the dilemmas faced by decision-makers in this sector. Plastic waste is thrown away in a coastal area or carried by a river that empties into the sea. The beach is considered as a landfill. The impact is very detrimental to the community, namely: pungent odours, unpleasant views, many flies as vectors of disease, and this plastic waste cannot be recycled, reused and reduced.

Disposed of plastic waste into a landfill, become carbon sink, combustion, furnace, gasification solution is not economical for tackling this problem due to toxic gas production and high production costs. Pyrolysis of plastic waste into fuel is one of the best ways to conserve precious petroleum resources in addition to protecting the environment. This process involves catalytic degradation of waste plastics into fuel-span hydrocarbons, e.g. gasoline, diesel and kerosene, etc. Currently, plastic waste or polypropylene waste can be converted into fuel by chemical conversion. Various technologies are being developed to overcome the drawback of plastics, namely, their non-biodegradability [3].

Though work has been done to make futuristic biodegradable plastics, there have not been many conclusive steps towards cleaning up the existing problem. Recycling plastic waste into reusable plastic products is a conventional strategy followed to address this issue for years. However, this technique has not given impressive results as cleaning and segregation of plastic waste was found difficult. Utilization of plastic waste for fuel was carried out on Tambaan Beach through the Doctoral Service program at Universitas Brawijaya. The population of Tambaan village is 4,110 people consisting of 2,050 men and 2,060 women [4]. Tambaan Beach is currently experiencing environmental degradation due to a large amount of plastic waste coming from the two rivers flowing into Tambaan beach. These two rivers are Gembong River from the east Pasuruan Regency and Welung River from the western Pasuruan Regency. Both rivers carry plastic waste. According to the Chairman of Karangtaruna Bina Hang Tuah, the amount of garbage in Tambaan Beach is around 1 ton per day. Figure 1 shows that image of plastic waste on Tambaan Beach.

![Figure 1. Location of plastic waste in Tambaan Beach](image-url)
2. Materials and Method

2.1. Materials

The technology product used to convert plastic waste into fuel is a distillator machine designed by Mr. Muryani who lives in Wlingi, Blitar Regency. Various types of plastic waste can be used as feedstock materials (Table 1). This distillatory technology is intended to reduce plastic waste to improve public health, reduce the generation of plastic waste, and provide added value, both socially and economically for the community.

Plastics are a non-biodegradable material [3]. Time needed to biodegrade is 300-500 years and therefore environmental hazards due to improper management include the following aspects: 1. Littered plastics spoil the beauty of the city and choke drains and make important public places dirty; 2. Garbage containing plastics, when burnt may cause air pollution by emitting polluting gases; 3. Garbage mix with plastics gives problems in landfill operation; and 4. Lack of recycling plant to posing an unhygienic problem to the environment.

| Plastic waste that can be processed | Plastic waste that cannot be processed |
|------------------------------------|--------------------------------------|
| PP (Polypropylene) is a type of plastic commonly used for packing / wrapping dry food / snacks, plastic straws, medicine bags, covers, plastic cups, bags, bottles, etc. | Mica Plastic is a type of plastic that is a mixture of PP / PE / PVC material consisting of limping clear mica plastic for albums, tablecloths, covers, wrappers, etc. and rigid mica film plastic for making boxes. |
| PE (Polyethylene) is a type of plastic that is commonly used for packing drinks or liquids, such as ice cubes, spare parts, screws, or other drinks | All plastics that contain aluminum foil |
| HDPE (High Density Polyethylene) is a type of plastic that is milky white or clean white. This type of plastic is used for tissue bags, detergent bottles, oils, heat-resistant plastics, plastic pipes, shopping bags and plastic bags that are common for vegetables that are soupy because they are flexible with high strength. | Bottled beverage packaging like water |
| LDPE (Low Density Polyethylene) is a type of plastic that is commonly used for coating cans, food wrapping plastics to keep it warm (food wrapping), grocery bags, bread wrappers, and plastic bags. This type of plastic is flexible with squeezing strength. | Raincoats and its like |
| PS (Polystyrene) is deformed and reads. This type of plastic is commonly used for corks (e.g. styrofoam, cups, boxes, meat trays, and egg cases). Plastic Vacuum is a type of plastic that is a mixture of nylon and PP / LDPE. Plastic Vacuum is used to wrap vegetables, fruit, meat which is empty and ready to be cooked and eaten. Polystyrene lunchbox is a type of plastic used for packing snacks, rice, etc. OPP (Oriented Polystyrene) is a type of plastic that is very clear, less heat resistant. Used for packing bread, snacks, t-shirts, clothes and jackets to add beauty and appearance to the product. It is normal that it is not easily torn using double layer side and gusset. | |
2.2. Methods

The distillator machine can be used effectively if plastic waste was dried before processing. This technology adopted the pyrolysis method and concept, which carried out using a certain temperature without oxygen to convert plastic waste into fuel oil. At a certain temperature, the plastics melt down and then turn to gas. Gas from the heating undergoes a cooling process and then forms a liquid, which then become fuel oil. Pyrolysis method can also be used to treat waste originating from households, such as garbage mix/food, fruit and vegetable waste, paper waste, plastic waste, and textile waste [5]. Waste processing with pyrolysis on average produced 52.2% waxed (liquid), 25.2% char/residue, 22.6% gas. Pyrolysis is a waste treatment that can reduce weight and volume of waste, and produce other products, include 1). gas containing low to the moderate calorific value as alternative fuel [6]; 2). char/residue from burning waste that contains the high calorific value also beneficial as an alternative fuel; 3). wax – potentially used as an alternative fuel and source of chemicals; and 4). pyrolysis water which contains organic ingredients.

![Pyrolysis reactor](image)

**Figure 2. Pyrolysis reactor**

The best results from pyrolysis treatment can be used as a fuel alternative in terms of calorie value. Based on the principles and procedures of pyrolysis, the method using a distillator machine was carried out by inserting as much as 10 kg of dried plastic waste into the reactor where 60% is distilled into diesel, 25% to premium and 15% distilled into kerosene [7]. The process takes 5-6 hours. Figure 3, 4, and 5 show a distillation machine designed by Mr. Muryani that is portable and mobile. The distillator machine has a capacity of 20 kg.
The workings of the distillator machine can be described as follows: a) For the capacity of 10 kg of plastic waste, when distillatory was operated at temperature of 75 °C, 1.5 L of premium was produced; b) At temperature of 120 °C, diesel fuel was generated but still in the dripping liquid. If the temperature was increased to 250 °C, then 6 L of diesel was produced. c) At temperature of 125 °C, as much as 1.5 L of kerosene was produced. The fuel used to operate the distillatory machine was LPG 3 kg for 10 kg of plastic waste. The LPG used must be ensured to provide a stable combustion as it can affect the transformation of plastic waste into liquid fuel. Therefore, using his technology, for each 10 kg of plastic waste can produce 6 L of diesel or 1.5 L of kerosene or 2.5 L of premium with PE plastic material and aqua glass lid. The combustion process takes 4 hours, which can produce 15 L of liquid fuel equivalent to diesel, premium, and kerosene. Type of plastic waste used is shown in Table 1 and Figure 6 and 7.

3. Results and Discussion

3.1. The involvement of youth organizing of Bina Hang Tuah

Before proceeding with a distillator machine, community participation needs to be done, to introduce to the community regarding the use of the distillator machine. For this reason, Bina Hangtuah Youth Organization was chosen as an actor to use a distillator machine. Youth organization is fully
responsible for the operation of its utilization. The handover of the equipment has been carried out between the person in charge of activities with the chairman of Karang Taruna Bina Hang Tuah and known by the Chairperson of UB’s LPPM. Youth organizations together with the community work together to collect, sort and dry the plastic waste that is suitable for processing. Given the vast coastal area of Tambaan, the process of collecting and drying also requires longer time. The problem involving the Youth lies in the ability to maintain this distillator machine. Karang Taruna has no financial and space resources. The Karang Taruna funds come from members, which mostly used for their operations. The cost for maintenance of the distillator device was estimated to be around IDR 1,500,000 including space to store machinery. Until now the machine is still placed at the storage warehouse in the Kelurahan office. Based on observations, if the engine was not used for 2 (two) weeks, the engine may experience instability of a decrease in temperature. Decrease in room temperature greatly affects the distillation process. If the room temperature is too cold, the distillation process cannot be operated in a longer time. Inversely proportional to the current state of an increase in room temperature, in which can fasten the duration of the distillation process [8].

3.2. The transformation process of plastic waste to fuels
Plastic is made from petroleum, so the process of converting plastic waste into fuel only returns plastic to its original form. The technology of converting plastic waste into fuel uses pyrolysis method, which is heating the plastic at a certain temperature without oxygen. At a certain temperature, the plastic is melted and then turn to gas. The gas from the heating process undergoes a cooling process and forms a liquid. The resulted liquid becomes the fuel in the form of plastic oil which is equivalent to diesel and premium.

3.3. The results of the distillator machine operation
The reactor tube looked like a box-shaped iron container that could be directly filled with plastic waste. After the plastic waste is ready, the reactor tube is connected to the stove at the right end of the machine. The process of burning plastic waste lasts approximately four hours. After that, the steam from burning plastic waste is transmitted through the cooling pipe and the steam undergoes sublimation process to turns the steam into liquid. That liquid is fuel oil. When it reaches the liquidity stage, another heating process is took place to transform the crude oil into kerosene, gasoline or diesel. The process of separating the oil particles is divided into three slots, with the final result being released through a tap of three in each slot. The results of the operation of the distillator machine showed the following results: Pyrolysis of plastic waste using a catalyst can reduce the pyrolysis temperature and reaction time, but it can increase the rate of conversion of plastic waste into premium fuels, gasoline or diesel. The distillator machine can process 20 kg of plastic waste weighing and produced approximately 12 L of diesel fuel, 2-3 L of kerosene and 2-3 L of premium. However, the quality of the fuel oil produced is still pure; therefore addition of octane is needed to increase energy and the fuel power if to be applied in the vehicle. For octane mixture, in every 5 L of premium, 3 octane pills (i.e. octane booster brand) is added. While in every 5 L of diesel, 2 octane pills is added.

3.4. Weaknesses of the distillator machine
This study also found that several disadvantages or weaknesses in using the distillator machine include: 1. The fuel produced is still pure, thus octane is needed to be added to provide more fuel power; 2. Comparison of premium with octane for every 5 L of premium need 3 octane pills, which implies additional cost is needed; 3. Stock of octane pills, which can be bought from motorcycle parts or chemical stores, are needed to enhance the fuel quality; 4. The operation of the distillator machine requires a longer time (i.e. 4 hours); 5. The human resources to supervise the distillers operation is still limited as many other workers from Karang Taruna have other permanent jobs; 6. Lack of time was allocated by the communities for collecting plastic waste, which limiting the stock of plastic waste to be transform into fuels. Thus, these conditions hinder the capacity of the distillator machine to produce fuels.
3.5. Maintenance of the distillator machine: future challenges
This study demonstrated that maintaining the operation of the distillation machine is still becoming a major obstacle in the community. There are various challenges to be tackled and need more attention. For example, seasonal weather changes, especially during rainy season which can delay the drying process of plastic waste. This is because the study showed that the distillator machine can optimally function if treating dried plastic waste. Another challenge is for the Bina Hang Tuah youth organization to study and follow the guideline for cleaning and maintenance of the machine. The cost of operating the distillator machine, such as energy and other expenses is needed to be carefully considered. The revenue from selling the produced fuels needs to be compared with the expenditures. Thus, the financial management needs careful attention for efficient performance of the distillator machine.

4. Conclusions
The findings showed that there were two aspects to be fully highlighted in the operation of the distillator machine, include technical aspects of machinery maintenance and business management aspects. The attention over the technical aspect is to ensure that the machine can give a superior performance in reducing volume of plastic waste and transforming into fuels. Shortening the distillation duration time is necessary to be considered to enhance the machine efficacy. For the business management aspect, strengthening the human resource capability through capacity building, assistance in business plan, marketing strategy and machinery operation are urgently needed. Both aspects may be the key to the success application of the distillator machine in the future.

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