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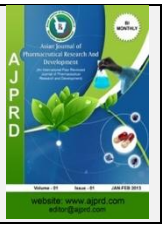

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Research Article

Processing Household Plastic Waste with the Pyrolysis Method into Fuel Oil in RW 03 Petir Village, Cipondoh, Tangerang

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A B S T R A C T

Garbage is one of the wastes from human activities, which can have a negative impact on humans and the environment. Based on data from the Ministry of Industry regarding imports of plastic products, it can be predicted that the amount of waste that will arise. Imports of Poly Ethylene Terephthalate (PET) and Poly Propylene (PP) products continued to increase in line with the growth in chemical consumption. One alternative is converting plastic waste into fuel oil. Because basically plastic comes from petroleum, so it just needs to be returned to its original shape. Pyrolysis or devolatilization is a process of fractionating materials by temperature. Pyrolysis is the process of decomposing a material at high temperatures in the absence of air or with limited air. Oil from used plastic has unsaturated properties. This means that the ratio between carbon and hydrogen is not balanced so that there are links that are not filled. This pyrolysis oil is flammable, emits soot, and has a stimulating odor. This pyrolysis oil can be processed again so that it has saturated and stable properties. It is hoped that processing plastic into oil can provide an alternative solution to the plastic waste problem and can also provide alternative fuel solutions that can be used in society. The general objective of this study was to determine the quality of fuel oil from household plastic waste using the pyrolysis method. The population that will be studied in this study is plastic waste obtained from residents in the settlement of RW 03 Petir Village, Cipondoh, Tangerang, Banten. The sample to be examined in this study was used plastic waste with 2 kg of each type of plastic waste. The results of identifying the types of plastic waste found that the generation of plastic waste generated in RW 03 was 101.75 kg with the highest proportion being PET waste (70.33%) and the lowest being the Other category. Testing of the tool was carried out based on the design results, namely a simple household-scale pyrolysis tool that can be used to process Poly Ethylene Terephthalate plastic waste. Trials were carried out twice on 1 kg of plastic waste type Poly Ethylene Terephthalate, which produced oil as fuel. There are still many shortcomings in the tools that are made including the tool is still not ergonomic, there is no high voltage indicator tool and the tool is not portable so it is still difficult to move.

Keywords: Plastic waste, household, pyrolysis, fuel oil

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INTRODUCTION

Public awareness in Indonesia to recycle waste is still relatively low. Based on the 2018 Indonesia Environment statistics released by the Central Bureau of Statistics (BPS), only 1.2% of households recycle their waste. Approximately 66.8% of households handle waste by burning it. In fact, the smoke generated from combustion can cause air pollution and interfere with health. As many as 32% of households choose other ways to handle their waste.[1–3]Garbage is a source of disease. Directly/openly waste is a nesting place for diseases, bacteria and pathogens. Indirectly, garbage is a place for vectors that can cause diseases such as diarrhea, dysentery, worms and dengue fever.[4–6]

The increase in the use of plastic for household purposes has an impact on increasing plastic waste piles. It cannot be treated using the landfill or open dumping method, plastic waste will have a negative impact on the environment because it cannot decompose quickly and its accumulation can reduce the quality of soil fertility.Plastic waste that is disposed of carelessly can also clog drainage canals and rivers, causing flooding. Destroying plastic waste by incineration is less effective and risks the appearance of pollutants from exhaust gas emissions (C02, CO, NOx, and

Sox) and several other polluting particulates, so other processing methods are needed to process plastic waste. Burning plastic waste can release substances that are harmful to human health.[7–9]

The increasing increase in plastic waste will become a serious problem if a solution is not sought. The most popular handling of plastic waste so far is the 3R (Reuse, Reduce, Recycle). Reuse is to use plastic items over and over again. Reduce is reducing the use of plastic goods, especially disposable items. Recycle is recycling goods made of plastic.[10,11]

Each of these waste handling has weaknesses. The weakness of Reuse is that certain items are made of plastic, such as plastic bags which, if used many times, become unusable. In addition, some types of plastic are not good for the health of the body when used many times. The downside of Reduce is the availability of plastic substitutes that are cheaper and more practical. While the weakness of Recycle is that the plastic that has been recycled will decrease in quality.[12,13]

Another alternative for handling plastic waste that is currently being researched and developed is converting plastic waste into fuel oil. This method is actually included in Recycle, but the recycling that is being carried out is not only turning plastic waste directly into plastic again. In this way, two important problems can be overcome, namely the danger of accumulating plastic waste and recovering petroleum, which is one of the raw materials for plastic.[14,15]

Several types of plastic that can be used as raw materials are Poly Ethylene Terephthalate (PET), High Density Poly Ethylene (HDPE), Poly Vinyl Chloride (PVC), Low Density Poly Ethylene (LDPE), Poly Propylene (PP), Poly Styrene (PS) and Other. Plastic production activities continue to increase as packaging or basic materials because it has the advantages of being lightweight, transparent, waterproof and relatively cheap and affordable for all people. Making plastic popular and widely used in aspects of human life. Every year plastic waste shows a significant increase, there is no definite data on the presentation of the amount of plastic waste according to the type.[16,17]

Based on data from the Ministry of Industry regarding imports of plastic products, it can be predicted that the amount of waste that will arise. Imports of Poly Ethylene Terephthalate (PET) and Poly Propylene (PP) products continued to increase in line with the growth in chemical consumption. In 2012, PET consumption in Indonesia was around 955,000 tons per year, which increased to around 1.03 million tons in 2013, and is predicted to increase to 1.11 million tons in 2014. Similar to PET, PP also continues to increase. in 2012, PP consumption was 1.3 million tons per year and increased in 2013 to 1.46 million tons. In 2014, PP consumption is predicted to increase to 1.58 million tons.[18]

The increasing use of PET and PP has caused the amount of PET and PP waste to increase rapidly which is increasingly being dumped in landfills, there is a need for alternative recycling processes that are more promising and have future prospects.One of them is converting plastic waste into fuel oil. Because basically plastic comes from petroleum, so it just needs to be returned to its original shape. In addition, plastic also has a relatively high calorific value, almost on par with fossil fuels such as gasoline and diesel. Several studies on the conversion of plastic waste into fuel-quality liquid products have been carried out and show results that are prospective enough to be developed.[19,20]

One method of waste processing that can be used to reduce waste is the pyrolysis method which can be used to treat household waste, such as mixed/food waste, fruit and vegetable waste, paper waste, plastic waste, and textile waste.[21]Pyrolysis or devolatilization is a process of fractionating materials by temperature. Pyrolysis is the process of decomposing a material at high temperatures in the absence of air or with limited air. The decomposition process in pyrolysis is also often referred to as devolatilization. The main products of pyrolysis that can be produced are charcoal, oil and gas. The charcoal formed can be used for fuel or used as activated carbon which contains charcoal/residue and inorganic materials contained in the raw material.[9]

The oil produced from the pyrolysis process is a complex mixture of organic compounds including styrene, ethyl-benzene, toluene, and others which can be used as fuel oil. While the gas formed produces gas consisting of hydrocarbons, CO, and CO2 which has a high calorific value which can be burned directly.The Poly Ethylene Terephthalate (PET) type plastic after a pyrolysis work test to produce a liquid similar to gasoline, after being separated based on a certain height/distance so that the temperature in each container is different and the specific gravity and carbon chain length. Based on an analysis conducted by the Oil and Gas Institute (Lemigas), oil from used plastic has unsaturated properties. This means that the ratio between carbon and hydrogen is not balanced so that there are links that are not filled. This pyrolysis oil is flammable, emits soot, and has a stimulating odor. This pyrolysis oil can be processed again so that it has saturated and stable properties.[22,23]

METHODS AND MATERIALS

This type of research is experimental in nature with the aim of knowing the quality of fuel oil using the pyrolysis method of household type plastic waste. Based on Sugiyono in the book Quantitative Qualitative Research Methods and R&D (2011), the research design is a one-shot case study.[24] The population that will be studied in this study is plastic waste obtained from residents in the settlement of RW 03, Petir Village, Cipondoh, Tangerang, Banten. The samples to be examined in this study were used plastic waste with 2 kg of each type of plastic waste.

The process of processing plastic waste, where the existing PET plastic waste is collected, then cleaned of residual water or dirt, then dried using sunlight. After the PET plastic waste is dry, the plastic waste is cut so that the size becomes small. After the small-sized pet waste is carried out by the pyrolysis process, this process produces waste in the form of gas and solid residue. After the pyrolysis process is complete, oil is produced which can be used as fuel. In this research, it is known that the temperature and pressure produced during 2 experiments.

RESULTSAND DISCUSSION

Table 1: Plastic waste generation in RW 03 Petir Village, Cipondoh, Tangerang

No	RT	Samples	Amount of Plastic Waste Generation				
			Week				Total
			1	2	3	4	
1	RT 01	8	2,13	1,95	2,04	1,95	8,07
2	RT 02	6	2,06	0,95	1,44	1,3	5,75
3	RT 03	10	2,07	1,45	2,64	2	8,16
4	RT 04	8	2,19	1,9	1,88	2,1	8,07
5	RT 05	8	2,38	1,65	2,7	1,5	8,23
6	RT 06	5	2,01	0,9	1,2	0,9	5,01
7	RT 07	10	2,33	2,43	2,3	2,6	9,66
8	RT 08	6	2,16	1	1,5	1,6	6,26
9	RT 09	6	2,1	1	1,3	1,2	5,6
10	RT 10	10	2,23	2	2,2	2,5	8,93
11	RT 11	5	2,16	1	1,3	1	5,46
12	RT 12	8	2,3	1,65	2,2	1,5	7,65
13	RT 13	9	2,35	1,7	2	2,3	8,35
14	RT 14	6	2,35	1,6	1,4	1,2	6,55
Total		**105**	**30,82**	**23,18**	**29,1**	**27,65**	**101,75**

Based on table 1, it shows that a sample of 105 houses generates plastic waste (101.75 kg) for 1 month, and the highest plastic waste generation is in the first week with plastic waste generation (30.82 kg) and the lowest is in the first week. secondly with generation (23.18 Kg), then the highest generation of plastic waste is in RT 7 with plastic waste generation (9.66 Kg) and the lowest generation is in RT 6 with generation (5.01 Kg).

Table 2: Composition of types of plastic waste in RW 03 Petir Village, Cipondoh, Tangerang

No	Types of plastic waste	Result (%)	
		Total (kg)	Percentage (%)
1	Poly Ethylene Terephthalate	71,56	70,33
2	High Density Poly Ethylene	14,16	13,92
3	Poly Vinyl Chloride	0,8	0,79
4	Low Density Poly Ethylene	1,9	1,87
5	Poly Propylene	7,33	7,20
6	Poly Styrene	5,9	5,80
7	Other	0,1	0,10
Total		101,75	100%

Based on table 2, it is known that the percentage of plastic waste composition is 101.75 kg with the highest waste production, namely the PET code of 70.33% and the lowest waste production, namely the Other code of 0.10%. The composition of the waste generated is influenced by various factors including the frequency of collection; season; socioeconomic level; product packaging; weather; income per capita.

The results of this study indicate that the composition of plastic waste in the settlement of RW 03 Petir Village,

Cipondoh, Tangerang, Banten is coded 1 (PET) plastic waste with a percentage yield of 70.33%, because PETE material is able to block oxygen, water and carbon dioxide from escaping or get into the packaging. Therefore, this material is very suitable for packaging soft drinks, mineral water, juices, mouthwashes and sauces. These packages are widely used in everyday life.

From the data above it is known that there is quite a lot of plastic waste in RW 03 Petir Village, Cipondoh, Tangerang, Banten. If this plastic waste is used and processed properly, it can reduce waste generation in RW 03. According to Law No. 18 of 2008 concerning Waste Management, all sources of waste must be able to process their waste so that the waste that is in place can be reduced. One form of processing plastic waste that can be carried out in RW 03 Petir Village is processing plastic waste into fuel oil, in addition to reducing the generation of plastic waste, there are other benefits, namely obtaining fuel oil.

Table 3: Results of temperature and pressure measurements during the processing of plastic waste into fuel

Measurement results	Time (Hour)	Temperature (^{0}C)	Pressure (psi)	Sample Change
Experiment 1	1	115	5	PET plastic begins to melt
	2	130	10	PET plastic begins to melt and generate steam
	3	150	10	PET plastic begins to evaporate and produce liquid smoke
Experiment 2	1	115	5	PET plastic begins to melt
	2	135	10	PET plastic begins to melt and generate steam
	3	155	10	PET plastic begins to evaporate and produce liquid smoke

Based on table 3, from the results of observations made in experiments 1 and 2 this lasted for 3 hours, and the results of temperature measurements during the experiment, it was seen that the temperature ranged from 115 to 155 OC and the pressure was between 5 - 10 psi. This is due to the pyrolysis process which is not perfect because the temperature is not high enough.The liquid smoke produced is in the form of a yellowish liquid with a pungent odor, while the solids from the combustion products have a margarine-like texture. After producing liquid smoke, a flame test is carried out using a match. Preliminary results of the experiment where PET type plastic waste processed by a household scale pyrolysis reactor produced 70 ml of fuel oil in the first trial and in the second trial it produced 72 ml. The process is still not perfect because there is still sludge attached to the reactor wall.

CONCLUSION

Based on the results of the study, it was found that there was a simple household-scale pyrolysis tool that could be used to process PET-type plastic waste. The trial was carried out twice on 1 kg of PET type plastic waste, producing oil as fuel. There are still many shortcomings in the tools that are made including the tool is still not ergonomic, there is no high voltage indicator tool and the tool is not portable so it is still difficult to move.

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