

# Waste-to-Energy (WTE) Method to Mitigate Harmful Environmental and Health Consequences Due to LDPE Plastic Waste

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**Submission date:** 25-Apr-2023 10:04AM (UTC+0800)

**Submission ID:** 2074638613

**File name:** 19\_Waste-to-Energy\_WTE\_Method\_to\_Mitigate\_Harmful.pdf (488.17K)

**Word count:** 2646

**Character count:** 13780

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To cite this article: Novarini *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **810** 012014

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## Waste-to-Energy (WTE) Method to Mitigate Harmful Environmental and Health Consequences Due to LDPE Plastic Waste

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**Abstract.** The increase in population accompanied by using LDPE plastic bags in households, traditional markets, and other shopping places impacts increasing LDPE plastic waste. This type of LDPE plastic waste is a problem because it has no sale value then buried in the landfill because of its non-biodegradable nature. So far, the method of decomposing LDPE plastic waste in order to reduce it has been carried out using the incineration method. Gas resulting from combustion in the combustion process causes pollution to the environment and disturbs the health of living things. This problem was solved by using the Waste to Energy (WTE) method, namely pyrolysis. LDPE plastic waste as a feed is converted to fuel oil using 1 unit of pyrolysis equipment by mixing it with a 1% zeolite catalyst at a temperature of 250°C for 6 hours. The volume of the conversion product is measured, and the characteristics of kerosene and diesel fuel are analyzed. The results of the analysis show that the converted fuel oil is a type of kerosene with the amount that can be converted is 1 ml of 1 gram LDPE plastic bag.

### 1. Introduction

The increase in population in an area impacts many waste products, especially inorganic waste, which causes various kinds of problems, especially problems with the environment. The majority of inorganic waste consists of types of plastic waste that cause environmental damage because it is non-biodegradable, causing negative impacts on the environment because it cannot be decomposed by microorganisms [1], [2], [3], [4], [5], [6], [7].

Based on its use of plastics can be categorized into seven types. The seven types of plastic are Polyethylene terephthalates (PET), High-Density Polyethylene (HDPE), Polyvinyl Chloride (PVC), Low-Density Polyethylene (LDPE), Polypropylene (PP), Polystyrene (PS), and others. The type of plastic can be seen in Table 1 [8], [9]:

**Tabel 1.** Types of Plastic

Type	Common uses
PET	Soft drinks, water bottles, containers, salad dressing, biscuit trays, and salad domes
HDPE	Shopping bag, freeze bag, bucket, shampoo, milk bottle, ice cream containers, juice bottle and chemical bottle.
Polyvynil Chloride	Cosmetic containers, plumbing pipe and fittings, electrical conduct, blister



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Type	Common uses
(PVC)	packs, wall caldding, roof sheeting, bottles, garden hose, shoes soles, cable sheathing, blood bags, and tubing
Low-Density Polyethylene (LDPE)	Refuse bags, irrigation tubing, mulch film, cling wrap, garbage bags, squeeze bottles.
Polypropylene (PP)	Microves dishes, lunch boxes, packaging tape, garden furniture, kettles bottles, ice cream tubs, potatoo chip bags and straws.
Polystyrene (PS)	CD cases, plastic cutlery, imtation glasswar, low-cost brittle toys, video cases/foamed polystyrene cups, protective packaging, building and food insulation.
Other	Automotive and appliance components, computers, electronics, cooler bottles and packaging.

Five of these types of plastic except for the type of LDPE plastic waste are taken and sorted by scavengers to be sold in terms of plastic mass, but scavengers do not take the type of LDPE plastic waste because it has no sale value and no plastic collecting agent wants to buy this type of plastic waste. This type of plastic waste from LDPE plastic bags is finally decomposed by incineration. Decomposition of plastic waste by incineration is risky to the environment because pollutants will appear from CO<sub>2</sub>, CO, NO<sub>x</sub>, and SO<sub>x</sub> exhaust emissions, which cause global warming and destroy the ozone so that other processing methods are needed to plastic processing waste [2], [10], [11], [12]. Other polluting particulates from the combustion of plastics are furans and dioxins. Dioxin substances, if inhaled by humans for a short time, can cause coughing reactions, shortness of breath, and dizziness. In the long term, dioxins can accumulate in the body, causing various cancers because it is carcinogenic [13], [14], [15].

Another condition if plastic waste is not decomposed and carried to water bodies such as rivers and oceans is the formation of microplastics in every natural resource from the oceans such as salt. More than 90% of the salt brands randomly sampled contained microplastics, with the highest source coming from Asia. This microplastic problem not only affects human health as salt consumers but also damages the food chain and all marine biota [16], [17], [18], [19], [20], [22].

Reducing, reusing, incineration, energy recovery, or commonly known as Waste to Energy (WTE), and mechanical recycling are several methods for managing plastic waste. WTE and recycling are two methods that are widely used to convert plastic waste into energy. Pyrolysis is one of the WTE methods that can be applied in processing plastic waste into energy in the form of liquid fuel and char and gas as an alternative to solvent environmental damage due to pollutants [2], [4], [15], [21]. The pyrolysis method is a chemical decomposition process using a temperature of 250°C - 450°C without using air. In this study, we recycled plastic bag waste using the pyrolysis process by taking the best pyrolysis time reference in the related research that the author did previously entitled Analysis of Temperature and Time Against Oil Fuel Results with Plastic Bag Waste Pyrolysis Process, which is 6 hours. However, the use of pyrolysis temperature in this study is the lowest temperature in the previous author's research to minimize energy use by developing a process, namely adding a catalyst, wherein previous studies the pyrolysis process did not use a catalyst. [2].

## 2. Materials and Methods

LDPE type of plastic waste used is a type of plastic wrap for food is often referred to in the community as plastic bags. Plastic bags are the focus of energy conversion as a solution to environmental and health problems which described in the introduction. The consideration of choosing this type of waste bag because this plastic waste is a contributor to much plastic waste and routinely produced by the community starting from households, markets, and modern shopping centers. Plastic bags are selected into dry waste and wet waste before being processed in the pyrolysis process. Dry

plastic waste can be used directly while wet plastic waste must be cleaned and dried before it can be used.

The materials in this study were LDPE type plastic waste and 1% natural zeolite catalyst [23]. The equipment in this study is 1 unit of LPG-fueled pyrolysis equipment consisting of a reactor, tar storage, and condenser. The reactor is made of 3 mm thickness stainless steel [24][25], 2.5 kg capacity, 450 mm height, and 320 mm diameter. It is coated with a glasswool to withstand the transfer of heat to the environment. The steel tar reservoir has a height of 200 mm and a diameter of 80 mm. The shell side of the condenser is made of steel with 600 mm height and 350 mm diameter. The tube side is a copper pipe with a diameter of 0.5 in and a length of 5,000 mm, which is formed in a spiral wound. The condenser outlet is a product of fuel oil as the energy produced.

The feeds are 2.5 kg of LDPE plastic waste, and 1% catalyst was introduced from the top of the reactor and heated at a temperature of 250 °C for 6 hours. After 6 hours, the volume of fuel oil condensed from the condenser was measured, and the characteristics of the fuel oil were analyzed, including the cetane index, specific gravity @ 15 °C, viscosity @ 40 °C, sulphur content, flash point, and calorific value to determine the fuel specifications obtained as a product of pyrolysis [15].



Figure 1. LDPE pyrolysis equipment

### 3. Result and Discussion

#### 3.1. LDPE Fuel Oil from LDPE Plastic Waste Conversion

Fuel oil as a product of the conversion of 2500 ml or 2.5 liters of LDPE plastic waste is shown in Figure 2 below:



Figure 2. Fuel converted from LDPE plastic waste

LDPE plastic waste conversion for the type of plastic bag as much as 2.5 kg produces 2.5 liters of fuel oil, so every 1 gram of LDPE plastic waste in the type of plastic bag can convert 1 ml of fuel oil. Table 2 shows the results of the analysis of the characteristics of fuel oil from the pyrolysis of LDPE plastic waste.

**Table 2.** The Results of Pyrolysis Fuel Product Characteristics

Parameter	Units	Kerosine	Diesel Fuel	Pyrolysis Fuel Oil
Cetane index	-		min 45	69
Density @ 15°C	kg/m <sup>3</sup>	max 836	min 815, max 860	779
Sulfur Content	ppm	Max 2,500	max 500	21
Kinematic Viscosity @ 40°C	mm <sup>2</sup> /s		min 2, max 44.5	0.61
Flash Point	°C	min 38	min 52	29.2
Caloric Value	MJ/kg	46.5	43.5-55.7	27.20
Obtained volume @ 200°C	% Vol	Min 18		91.01

The results of the analysis show that the resulting fuel oil product meets kerosene standards except for the aspect of caloric value and flashpoint. Standard specification characteristics have been defined by ASTM Standards, according to Table 2 [27].

#### 4. Conclusions

Environmental problems, pollution, global warming, and health due to the impact of LDPE plastic waste in the plastic bag type can be dissolved by one of the Waste to Energy (WTE) methods, namely the pyrolysis using zeolite catalysts at temperatures of 250 °C for 6 hours. The conversion of LDPE plastic waste produces 1 ml fuel oil for every 1 gram conversion of LDPE plastic waste.

#### References

- [1] Alam M N, Charisma dan Suaedi 2019 *Pyrolysis of Polypropylene ( PP ) Into Liquid Fuel Using CaO Catalyst (Int. Conf. on Natural & Social Sciences Vol 2)* ed E Wahyono (Palopo : Indonesia) p 1
- [2] Novarini, Porawati H and Darmuji 2018 Analysis of Temperature and Time on the Result of Fuel Oil *J. Inovator* 1 1
- [3] Bow Y, Zulkarnain, Lestari S P, Sihombing S R M, Kharissa S A and Salam Y A 2020 Processing of Low Density Polyethylene (LDPE) and Polypropylene (PP) Waste Into Alternative Liquid Fuels Using a Pyrolysis Thermal Cracking Prototype *J. Kinetika* 9 1
- [4] Joshi A and Punia R 2014 Conversion of Plastic Wastes into Liquid Fuels-a Review Micro Gasifier Designing View Project Plastic Wastes Management View Project *Recent Advances in Bioenergy Reaserch* III 2-6
- [5] Miandad R, Rehan M, Nizami A S, Barakat A E dan Ismail I M 2016 *Recycling of Solid Waste for Biofuels and Bio-chemicals (Springer)* Vol 1 ed O P Karthikeyan, K Heimann dan S S Muthu (Berlin) p 336
- [6] Mafruddin M, Dharma U S and Nuryanto A 2017 The Effect of Condensor Pipe Geometry on Heat Transfer in Plastic Oil Distillation *J. Mechanical Eng. Universitas Muhammadiyah Metro* 6 1
- [7] Bow Y, Rusdianasari and Lestari S P 2019 *Pyrolysis of Polypropylene Plastic Waste into Liquid Fuel (Int. Conf. on Sustainable Agriculture Vol 347)* ed M Direk (Manila : Philippines) p 1
- [8] Alabi O A, Ologbonjaye K I, Awosolu O and Alalade E 2019 Public and Environmental Health Effects of Plastic Wastes Disposal: A Review *J. Toxicol. Risk Assess* 5 2-4
- [9] Miandad R, Barakat M A, Rehan M, Aburizaiza A S, Ismail I M I, and A. S and Nizami A Z 2017 Plastic Waste to Liquid Oil Through Catalytic Pyrolysis Using Natural and Synthetic Zeolite Catalysts *J. Waste Management* 69 2
- [10] Nindita V 2015 Study of Various Methods of Making Fuel from Plastic Waste of LDPE and PVC Types using the Thermal & Catalytic Cracking Method (Ni-Cr/ZEOLIT) *J. Teknis* 10 2

- [11] Rhodes C J 2018 Plastic pollution and potential solutions *J. Science Progress* 101 13
- [12] Moulita R A N, Rusdianasari and Kalsum L 2020 Biodiesel Production from Waste Cooking Oil using Induction Heating Technology *Indonesia J. of Fundamental and Applied Chemistry (IJFAC)* 5 1
- [13] Yusmartini E S and Rusdianasari 2016 *Separation process Biodiesel from Waste Cooking Oil using Ultrafiltration Membranes (Proc. Forum in Research, Science, and Technology (FIRST) Vol 1)* ed Rusdianasari and T Dewi (Palembang : Indonesia) p 1
- [14] Yunsari S, Husaini A and Rusdianasari 2019 Effect of Variation of Catalyst Concentration in The Producing of Biodiesel from Crude Palm Oil Using Induction Heater *Asian J. of Applied Research for Community Development and Empowerment (AJARCDE)* 3 2
- [15] Rusdianasari, Bow Y and Moulita R A N 2020 Temperature Effect on the Biodiesel Quality from Waste Cooking Oil by Induction Heating *J. of Physic: Conference Series* 1450 2-5
- [16] Verma R, Vinoda K S, Papireddy M and Gowda A N S 2016 *Toxic Pollutants from Plastic Waste- A Review Procedia Environ (Proc. Environmental Science Vol 35)* ed S K Ghosh (United Kingdom) pp. 13–14
- [17] Sidjabat F M, Ismail Y and Rismauli E 2019 Plastic Pollution Awareness di Desa Jatireja Cikarang Jawa Barat *Academics in Action J.* 1 2
- [18] Azharman Z, Meldra D, Mardiansyah Y and Damanik Y M 2019 Proposal for the Design of a Pyrolysis Reactor to Convert Plastic into Oil Fuel *J. SNISTEK* 2 1
- [19] Rusdianasari, Syarif A, Yerizam M, Yusi M S, Kalsum L and Bow Y 2020 Effect of Catalyst on the Quality of Biodiesel from Waste Cooking oil by Induction Heating *J. of Physic: Conference Series* 1450 1
- [20] Susumu S, Rusdianasari and Yusi S 2018 Biodiesel Production from Waste Cooking Oil using Electrostatic Method *Indonesia J. of Fundamental and Applied Chemistry (IJFAC)* 3 2
- [21] Yunsari S, Rusdianasari and Husaini A 2019 CPO Based Biodiesel Production using Microwaves Assisted Method *J. of Physics* 3 3
- [22] Anzar E, Yusi S and Bow Y 2018 Purification of Crude Glycerol for Biodiesel By-product by Adsorption using Bentonite *Indonesia J. of Fundamental and Applied Chemistry (IJFAC)* 3 2
- [23] Putra J U, Kalsum L and Bow Y 2018 Effect of DC Voltage on Prototype of Biodiesel Electrostatic separator with Glyserin from Waste Cooking Oil *Indonesian J. of Fundamental and Applied Chemistry (IJFAC)* 3 3
- [24] Ploetz R, Rusdianasari, and Eviliana E 2016 *Renewable Energy: Advantages and Disadvantages (Proc. Forum in Research Science, and Technology (FIRST) Vol 1)* ed Rusdianasari and T Dewi (Palembang Indonesia) p 3
- [25] Trisunaryanti W 2002 Optimation of Time and Catalyst/Feed Ratio in Catalytic Cracking of Waste Plastics Fraction to Gasoline Fraction Using Cr/Natural Zeolite Catalyst *Indonesian J. Chemistry* 2 2
- [26] Kunwar B, Cheng H N, Chandrashekar S R and Sharma B K 2016 Plastic to Fuel: A Review *Advances in Applied Energy J.* 54 422
- [27] Thahir R, Altway A, Juliastuti S R and Susianto 2019 Production of Liquid Fuel from Plastic Waste Using Integrated Pyrolysis Method with Refinery Distillation Bubble Cap Plate Column *Energy Reports J.* 5 4-5

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