# Post Seaweed Cultivation Bottled Utilization for Fuel Alternative Production by Pyrolysis Method: A Review

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**Abstract.** A seaweed cultivator has an average of 400-5,000 ropes, where 1 ha of water area can be installed around 800 ropes. It delivers to the increasing the number of plastic bottle waste. The plastic bottles are used as floats in seaweed cultivation. Plastic bottle waste is an environmental problem for the community. Plastic waste triggers the degradation of coastal ecosystems and causes damage to coastal ecosystems. The handling of plastic bottle waste has been done by recycling, however, the large number of plastic waste still exist. Recycling only change plastic waste into other form. Converting plastic waste into fuel is believed to reduce the amount of waste and increasing the economic value itself. The fuel produced bring the benefit for the society. By applying pyrolysis method, it can decomposed with heat energy asistance. The temperature used is above 150°C. The purpose of this narrative review is to find out the potential of plastic waste processing other than recycling to make it more useful for the the cultivation society. Further research is expected to be carried out and the results can be used by the community to reduce plastic bottle waste.

**Keywords:** Plastic Waste, Pyrolysis, Fuels.

## 1. Introduction

Seaweed cultivation is the main livelihood for people in Nunukan District, North Kalimantan. One cultivator has an average of 400-5,000 ropes, where 1 ha of water area can be installed around 800 ropes. An expanse can produce about 13-15 kg of dry seaweed during the peak seaweed season, and about 5 kg of dry seaweed during poor growing season conditions [1]. This achievement is proportional to the amount of plastic bottle waste generated. The plastic bottles used are former bottled drinking water and are used as floats in seaweed cultivation. Based on [2] explained that seaweed farmers in Nunukan Regency produce 25 tons of used bottle waste per harvest period.

The amount of plastic waste is a persistent environmental problem and has an impact on the community around the cultivation area. In terms of utility, plastic is a much-needed material due to its diverse functions in households and industries [3]. Plastic waste has a large volume. It has problematic with its disposal. This happens because plastic has a very long biodegradation time and pollutes the environment.


M. U. H. Al Rasyid and M. R. Mufid (eds.), *Proceedings of the International Conference on Applied Science and Technology on Engineering Science 2023 (iCAST-ES 2023)*, Advances in Engineering Research 230,
https://doi.org/10.2991/978-94-6463-364-1_56

According to the research [4] stated that plastic waste causes damage to coastal ecosystems by contributing 90% of waste in the ocean, thus triggering the degradation of coastal ecosystems.

Plastic waste must be controlled in an appropriate utilization. Recycling plastic waste is a way to handling plastic problem. It processes and changes into new plastic materials. However, this recycling process will only make plastic into a new form, not to reduce the amount of plastic waste [5]. Reducing the amount of plastic waste can be done by turning it into fuel [6]. This alternative is expected to provide a solution to the waste problem and provide more benefits in the form of fuel that can also be used by the society [7].

## 2. Method

The composing of this Narrative Review begins with the latest issues identification, arrange the main idea, literature study, data analysis, and writing the manuscript. This review is arranged to investigating the potential plastic bottle waste from seaweed cultivation that can be converted into fuel. The results are expected to reduce environmental pollution due to plastic bottle waste and produce fuel that can be utilized by the local community.

## 3. Discussion

### 3.1 Recycling Category

Recycling process has several categories, namely, primary, secondary, tertiary, and quaternary. Based on [3] explains that primary recycling is also known as mechanical reprocessing. The secondary recycling process is contaminated waste that has been cleaned. Tertiary recycling is also known as cracking process, the process includes breaking down plastics at high temperatures (thermal degradation) or at lower temperatures with a catalyst (catalytic degradation), which contains smaller carbon chains. Quaternary recycling focuses on recovering the energy content of plastics. Controlled combustion in the presence of air can convert waste into Carbon dioxide and water [8].

### 3.2 Converting Waste into Fuel by Pyrolysis Method

Converting plastic waste into fuel method include: pyrolysis, thermal cracking, and catalytic cracking [5]. The pyrolysis method is the decomposition of biomass by heat at temperatures greater than 150°C [6]. Pyrolysis is the most valuable method. According to [9] the pyrolysis method can convert large amounts of plastic waste up to 80% into fuel.

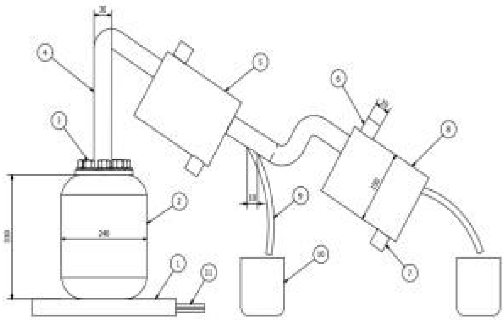

**Fig. 1**. Schematic of plastic pyrolysis device [10]

Based on [3] there are several types of pyrolysis processes; conventional, fast or flash pyrolysis. Conventional pyrolysis (slow pyrolysis) works under low heating and produces a significant portion of solid, liquid, and gaseous products. It is usually used for charcoal production, and the vapor produced can be discharged continuously. Fast pyrolysis is the heating of a material, such as biomass, at a high temperature without involving oxygen. Currently, fast and/or flash pyrolysis processes are more widely used due to time efficiency. The range of operator parameters for pyrolysis is shown in Table 1.

**TABLE 1** PYROLYSIS PROCESS OPERATING PARAMETERS

| **Parameters** | **Conventional** | ***Fast*** | ***Flash*** |
|---|---|---|---|
| *Pyrolysis Temperature (K)* | 550 – 900 | 850 – 1.250 | 1.050 – 1.300 |
| *Heating Rate (K/s)* | 0,1 – 1 | 10 – 200 | >1.000 |
| *Particle Size (mm)* | 5 – 50 | <1 | <0,2 |
| *Solid Residence (s)* | 300 – 3.600 | 0,5 – 10 | <0,5 |

(**Source:** Mohan in [3])

The important steps in plastic pyrolysis based on [3] are as follows:

1. Heats the plastic evenly without excessive temperature variations
2. Release the oxygen from the pyrolysis chamber
3. Managing carbon char by-products before they turn into thermal insulators and decrease heat transfer to the plastic
4. Careful condensation and fractionation of pyrolysis vapor to produce good quality and consistent distillate

The effort to overcome ecological and environmental damage can be done with the pyrolysis method, processing pre and/or post-use management of plastic waste can be done effectively and reduce mass hoarding [11]. Research results [12] stated that pyrolysis degrades plastic materials with a temperature range of 300-500°C to become gas and condensed, then distilled to produce oil and charcoal as residue. Various types of plastic waste such as HDPE, PET/PETE, PP, and PVC can be converted into fuel [13]. Using the pyrolysis method is an effective way to reduce the volume of plastic waste rather than recycling.

### 3.3 Plastic Waste

There are various types of plastic waste including Polypropylene (PP), Polyvinyl chloride (PVC), Nylon 6, Polystyrene (PS), High-Density Polyethylene (HDPE), Low-Density Polyethytele (LDPE), and Linear Low-Density Polyethylene (LLDPE) [14]. Based on [15] the most widely used thermoplastic polymer is Polyethylene terephthalate (PET/PETE). PET is widely used for the manufacture of synthetic fibers, video and audio tapes, photographic films, food packaging, soft drink bottles and water bottles, etc. [16]. PET is a semicrystalline thermoplastic with high strength, good mechanical and chemical resistance properties [17].

The use of PET has a significant contribution to human life, however, the presence of waste generated poses a serious problem for the environment. It takes about 300-450 years for plastic end products to decompose naturally [18]. In 2010, plastic usage reached 2.4 million tons and increased to 2.6 million tons in 2011 [5]. This is equal with the increase in the amount of plastic waste generated.

### 3.4 Plastic-Waste Fuel

The quality of fuel produced by the pyrolysis method has various parameters. The parameters are temperature, pyrolysis time, catalyst use, and the type of waste used [19]. Supporting this description, the type of plastic used as raw material can affect the quality and characteristics of the fuel produced [20]. Therefore, the selection of plastic types for raw materials must be considered properly so that the results are in accordance with the standards.

Polyethylene terephtalete (PET/PETE) is a type of thermolpastic made from a ratio of 30% monoethylene glycol (MEG) with 70% terephtalic acid (TPA), has a label of 1 and a melting point of 250°C [21]. The manufacture of fuel made from plastic bottles (PET/PETE) with the pyrolysis method produces yellowish powder material that sticks to the pipe line [22]. Then [23] stated that 500 grams of plastic waste produced an average volume of 27 ml of oil with a density of 794 kg/m$^3$, a viscosity of 1.2 cP, a thick orange yellow color, and a pungent odor. Pyrolysis of PET waste can be used as a liquid fuel although, it is not better than HDPE when used as raw material [19]. PET plastic does not provide maximum results in both quantity and quality of fuel products when compared to other types of plastic.

Based on this description, PET plastic waste can be used for fuel but the quality is not good. Research conducted by [10], the oil produced in the pyrolysis process varies from 330-360 ml for the pyrolysis oil yield of about 368 ml for PET (polyethylene terephthalate). Based on [5] explained that the pyrolysis oil produced from 500 grams of PET plastic waste was 90 ml with a combustion time of 6.51 minutes, faster than kerosene (7.23 minutes) and longer than premium oil (5.12 minutes). The results of research conducted by [24] show that the manufacture of fuel using PET/PETE plastic waste raw materials has a heating value ranging from 10572-10860 cal / g, density 0.75-0.77 g / ml, and kinematic viscosity ranging from 0.39-0.80 cSt. These results are in accordance with commercial fuel oil standards. The detailed standards and specifications of fuel oil are presented in Table 2 below.

**TABLE 2** FUEL STANDARDS AND SPECIFICATIONS

| **Fuel types** | **Viscosity (cP)** | **Density (kg/m$^3$)** | **Calorific value (MJ/kg)** |
|---|---|---|---|
| Gasoline | 0,652 | 715-850 | 47,3 |
| Solar | 2-4,5 | 820-850 | 46,5 |
| Kerosene oil | 0,294-3,34 | 780-810 | 43 |

(**Source:** [24], [25])

## Conclusion

Based on the results of the discussion above, the use of pyrolysis method to reduce plastic bottle waste is considered effective. Although plastic bottles (PET/PETE) as raw materials are not better than other types of plastic, the results show that they meet the standards of commercial fuel oil. In addition, the pyrolysis method is more effective because it can produce fuel than the recycling method.

## Acknowledgment

Thanks to Politeknik Negeri Nunukan for facilitating the writing of this narrative review.

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