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Portable Incinerator Capacity of 5000 Grams with Used Fuel Oil

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Abstract. Waste is a significant problem that needs to be urgently addressed. If waste is left untreated and disposed of improperly, it can become contaminated by bacteria, viruses, and other toxins that pose serious risks to humans. In this study, researchers designed and created a portable incinerator that utilizes used oil fuel. The study aimed to determine the highest temperature that can be achieved when incinerating wet and dry waste at weights of 5000 grams, 3000 grams, and 1000 grams. Additionally, performance of portable incinerator was evaluated based on the combustion rate and fuel consumption. The result show that the maximum temperature generated by both dry and wet waste is 450 degrees Celcius. The maximum volume of waste that can be loaded into the combustion chamber is 5000 grams. The results show that the maximum combustion rate of the portable incinerator for dry waste weighing 1000 grams is 196.85 gr/s.The maximum burning rate for wet waste weighing 1000 grams is 165.56 gr/s. The minimum fuel consumption produced from dry waste weighing 1000 grams is 300 ml of used oil. And the maximum fuel consumption is produced from wet waste weighing 5000 grams, namely 1000 ml of used oil.

Keywords: Burner, Furnace, Incinerator

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1. Introduction

The disposal of medical waste generated from the Covid-19 pandemic has emerged as a critical concern, raising pivotal questions regarding its safe and efficient management. The urgent need to address this issue stems from the unprecedented surge in healthcare waste due to the pandemic's prolonged duration and unique characteristics.

Covid-19 is an infectious disease caused by the SARS-CoV-2 virus. Despite efforts to control its spread, the virus continues to affect populations worldwide, leading to a significant number of cases. Blora Regency, located in Central Java, has also experienced the impact of this global pandemic. Until

February 28, 2021, there were a total of 5,550 Covid-19 cases reported in the region, with 4,908 individuals recovering, 396 people under surveillance, and 246 fatalities[1]. These statistics serve as a reminder that vigilance and strict adherence to health protocols are necessary to prevent a further increase in Covid-19 cases in the Blora area.

In recent times, allegations of improper disposal of Covid-19 medical waste have surfaced. In one instance, medical waste, including infectious and hazardous materials, generated from hotels housing asymptomatic Covid-19 patients or those with mild symptoms, was reportedly disposed of carelessly in Tangerang City. The Bogor Resort Police took action by summoning the parties involved in this case of irresponsible waste disposal at the Toll Rest Area and TPS [2].

Improper management of medical waste, categorized as toxic and hazardous materials (B3), can pose potential risks to both human health and the environment. Environmental pollution resulting from the mishandling of medical waste can have adverse effects on individuals and communities. The entire waste management process, from collection and storage to transportation and disposal, presents potential hazards. These hazards include aesthetic disturbances, foul odors, and the creation of breeding grounds for viruses and nuisance animals . Certain compounds found in medical waste, such as pesticides used to eradicate insects or animals and radioactive materials, may even cause genetic disorders or damage to the human reproductive system [3] [4].

Medical waste categorized as B3 waste comprises materials that cannot be reused and may be contaminated with infectious substances or have come into contact with Covid-19 patients or healthcare staff. Such waste includes used masks, gloves, bandages, tissues, plastic items, syringes, infusion sets, personal protective equipment (PPE), and leftover patient food, among other items. These materials originate from various healthcare service areas, including emergency rooms, isolation rooms, intensive care units, treatment rooms, and other service rooms [5].

To address the proper management of Covid-19 medical waste, the Circular of the Minister of Environment and Forestry Number SE.2/MENLHK/PSLB3/PLB.3/2020, dated March 24, 2020, provides guidelines for the handling of infectious waste and Portable waste related to Covid-19. The circular outlines steps for managing infectious waste at home, such as cutting medical masks before disposal, segregating infectious waste in closed containers labeled "Waste Infectious," and designating specific collection locations before transferring the waste to authorized B3 waste processors [6]. These regulations emphasize the need for distinct handling procedures for Covid-19 medical waste compared to general Portable waste, especially for patients undergoing independent isolation at home. In this context, the development of a tool suitable for at-home use during the final disposal process of Covid-19 medical waste becomes essential. One such tool is a portable incinerator designed specifically for the treatment of waste generated by Covid-19 patients.

Previous research on this topic has explored various aspects of medical waste management related to Covid-19. A study in 2021 titled "Covid-19 Medical Waste Processing Vehicle Design" focused on integrating medical waste management with vehicles [7]. Although this research provided valuable insights, there are still obstacles in managing Covid-19 medical waste through local wisdom, as identified in the study conducted by [3] titled "Covid-19 Medical Waste Management through Local Wisdom." This study employed a literature review methodology, using secondary data sources to explore the challenges faced in managing Covid-19 medical waste through local wisdom. It emphasized the importance of government efforts in conducting counselling sessions and increasing supervision to enhance community participation in the management of Covid-19 medical waste through local wisdom.

The use of used oil as fuel of the incinerator has been developed by [8]. The objective of their research was to understand the functionality of the incinerator, test its parameters, such as temperature and waste capacity, and evaluate its efficiency. The incinerator consisted of five main components: the main combustion chamber, chimney, filtering chamber, fuel tank, and burner furnace. The dimensions of the main combustion chamber were 930 x 580 mm, with a waste volume capacity of 0.245 m³ or 8-15 kg per burn. The highest temperatures achieved during the combustion process were recorded as 443.2°C for dry leaf waste and 480.7°C for dry plastic waste. The efficiency of the incinerator was measured at 96.94% for dry leaf waste and 90.68% for dry plastic waste.

An experimental study titled "The Effectiveness of Used Oil Burner Incinerator Design and Construction," the research utilizes used oil as an alternative fuel and constructs an iron-based apparatus designed like a stove. In this study, the incineration process is conducted at specified temperatures ranging from 100°C to 250°C until the waste is reduced to ash. This combustion process can generate heat energy compared to open-air burning [9].

Another research study on an oil-based incinerator titled Design and Construction of an Incinerator Device Using Used Oil [8] addresses the issue of waste management. Open-air waste burning can cause disturbances and air pollution in the surrounding environment. This study aims to design and create an incinerator device that utilizes waste oil as fuel, capable of burning waste and transforming it into smaller and more manageable forms. This process produces sterile combustion residue that can be directly disposed of in the soil. The energy generated by the incinerator device can also be used as an alternative energy source for heating or drying. The combustion process requires temperatures ranging from 200°C to 300°C to reduce waste that cannot be recycled and completely burn it to ash.

The objective of this paper is to systematically address the Covid-19 or any future pandemic associated medical waste problem. Based on the existing research gap and the potential benefits of a portable incinerator for Covid-19 medical waste management, the present study aims to develop a device referred to as Portable Incinerator with a capacity of 5000 grams using used oil fuel. This incinerator utilizes used oil as a fuel source and is designed to facilitate the processing of waste generated by Covid-19 patients. The scalehold incinerator offers a practical and efficient solution for the final disposal of medical waste, ensuring the proper treatment and prevention of potential environmental and health hazards.

1.1. Incinerator

The incinerator is a device used to burn solid waste and operates by utilizing combustion technology at a specific temperature until the solid waste is transformed into gas and ash. The most commonly applied types of incinerators for burning hazardous solid waste are portable head, multiple hearth, and fluidized bed [10].

1.2. Portable Head Incinerator

The Portable Head Incinerator is a device used to burn both wet and dry waste and can be operated by utilizing combustion technology at a specific temperature. This device is capable of destroying waste such as masks, gloves, and tissues. The temperature during the incineration process of this device reaches 400°C to 700°C. The fuel used for this device is liquefied petroleum gas (LPG) and charcoal, which serves as auxiliary fuel for heat within the combustion chamber.

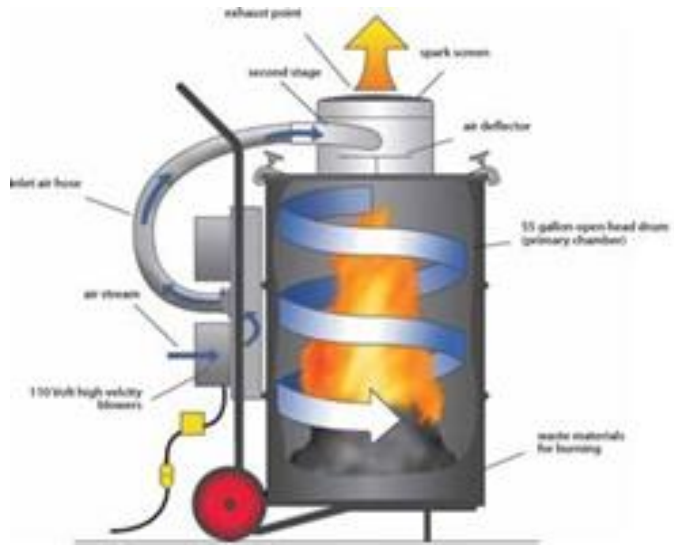

Figure 1. Insinerator Head Portable [10]

1.3. Multiple Hearth Incinerator

Multiple Hearth Incinerator consists of a framework of fire-resistant steel layers with a series of vertically arranged hearths, one above the other, usually numbering 5-8 hearths. The waste feed is continuously introduced from the top of the hearths, and the ash resulting from the combustion process is discharged. The burner is installed on the side wall of the combustion hearth where the combustion takes place, with air being fed from below and waste being fed from the top.

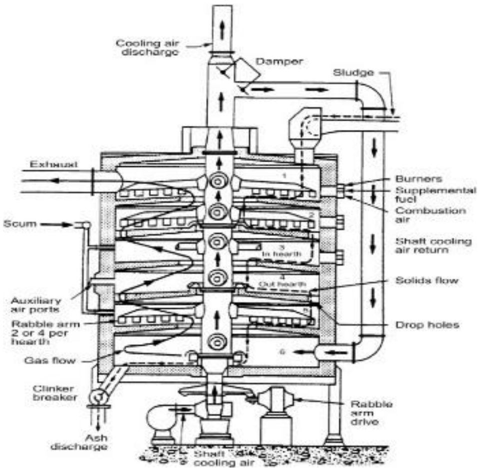

Figure 2: Multiple Hearth Incinerator [10]

1.4. Fluidized Bed Incinerator

The fluidized bed incinerator is a combustion chamber that utilizes a mixing medium such as sand, such as quartz sand or silica sand, to achieve homogeneous mixing between the air and the sand particles. The constant mixing between the particles promotes rapid heat transfer and complete combustion

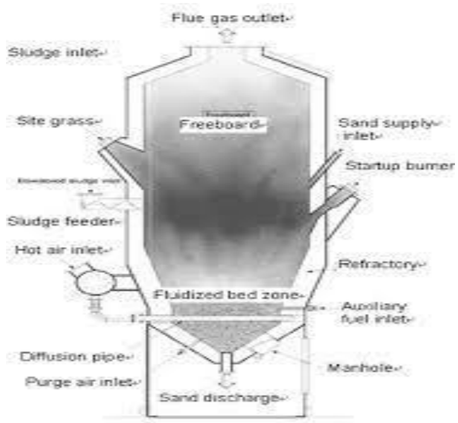

Figure 3: Fluidized Bed Incinerator [10].

1.5. Fuel

Used oil is one of the suitable fuel criteria for this incinerator, in line with the urban and regional development where the volume of used oil continues to increase with the growing number of motor vehicles and other motorized machines. Even in rural areas, small workshops can be found where one of the waste products is used oil. In other words, the distribution of used oil is already widespread from large cities to rural areas throughout Indonesia.

1.6. Combustion Process

The combustion process generally occurs in two ways: complete combustion and incomplete combustion. Complete combustion is a process where all carbon reacts with oxygen to produce CO_2, while incomplete combustion is a process where the fuel is not fully burned, resulting in incomplete conversion to CO_2.

1.7. Combustion Gas

In the combustion process, oxygen is provided with an excess air-to-fuel ratio to achieve complete combustion reactions. The main reaction of the combustion process between carbon and oxygen will produce carbon monoxide (CO) and carbon dioxide (CO_2).

1.8. Combustion Rate

Combustion Rate The combustion rate testing is a process of burning waste to determine the burning duration of a fuel and then weighing the mass of the burned waste. The ignition time is measured using a stopwatch, and the mass of the waste is measured using a digital scale [11]. The equation used to determine the combustion rate is as follows in equation (1).

$$\text{Combustion rate} = m/t \quad (1)$$

Explanation :
m = Mass of remaining burned material (grams)
t = Burning time (minutes)

2. Methods

In this methode is consist of design specifications, operational procedures, and data collection methods.

2.1 Design Specifications

Part of portable incinerator can describe in Figure 4 below.

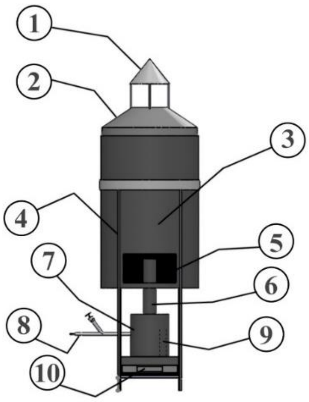

Figure 4: Part of Portable Incinerator

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Figure 4 describe the portable incinerator that consists of several parts, namely:

1. Smokestack. The smokestack functions to release the residual smoke from combustion and expel pollutants contained in the exhaust gases into the air.
2. Combustion Chamber Door. It serves to input various waste materials into the combustion chamber.
3. Combustion Chamber. It functions as the location for burning the waste materials and acts as a filter for the residual combustion.
4. Support Pillar. Its purpose is to support the weight of the incinerator.
5. Ash Residue Drawer It is used to collect the remaining ash or combustion residues from the waste materials.
6. Flame Stack. Its function is to emit flames to burn the waste materials inside the combustion chamber.
7. Burner. It serves as a container to store boiled water for generating steam inside the burner.
8. Water Inlet. It is a hole for adding water into the burner.
9. Nozzle. It is the opening where steam from the burner will come out and meet the flame from the fuel source. This process will propel the flame upward towards the flame stack.
10. Fuel Compartment. Its function is to hold used oil as fuel for the ignition process.

Specifications of the design a portable incinerator can describe in tsble 1 below.

Table 1. Portable Scale Incinerator Specification Data

Name	Dimension
Fuel Compartment	220 x 150 x 30 mm
Combustion Chamber	D = 380 mm, H = 590 mm
Combustion Chamber Door	D= 380 mm, H = 120 mm
Water Inlet	D= ½ inch, L = 220 mm
Nozzle	H = 140 mm, D= ½ inch
Burner	D = 6 inch, H = 170 mm
Flame Stack	D = 2 inch, H = 220 mm
Ash Residue Drawer	L = 210 mm, W = 100 mm
Support Pillar	H = 800 mm, L = 290 mm
Smokestack	H = 200 mm

2.2 Operational Procedures

There is an operational procedures for operating the incinerator portable :

1. Preparation of materials
   Gather an adequate amount of oil and water as required for the operation.
2. Water inlet setup
   Pour the prepared water into the designated water inlet connected to the burner.
3. Fuel compartment preparation:
   Pour the prepared oil into a small tray specifically designed for the fuel compartment.
4. Ignition process
   Ignite the oil within the fuel compartment using a safe and approved method.
5. Waiting period
   Allow approximately 8-10 minutes for the water inside the burner to reach boiling point and produce steam.
6. Flame generation
   As steam is generated, expect the emergence of a large flame passing through the designated flame stack.
7. Waste Input

Once the flame is established, carefully introduce the waste materials into the combustion chamber for incineration.

8. Monitoring and safety
   Regularly monitor the incineration process to ensure proper combustion and safe operation. Adhere strictly to safety protocols during waste input and combustion phases.
9. Emission process:
   Expect the emission of smoke resulting from the incineration process through the designated smokestack.
10. Post-Operation Protocol:
    After completion, allow the incinerator to cool down before any maintenance or further operation. Then dispose of any remaining waste material properly as per regulations and guidelines.
11. Maintenance and Cleaning:
    Perform routine maintenance and cleaning of the incinerator as per manufacturer's instructions and maintenance schedule.
12. Documentation:
    Keep detailed records of operational activities, maintenance, and any incidents for reference and regulatory compliance.

These operational procedures followed meticulously to ensure safe and efficient operation of the incinerator while complying with all safety and environmental regulations.

2.3 Data Collection Methods.

2.3.1 Data of Incinerator Furnace

Based on the provided information about the portable incinerator device and its capacity calculation, here are some data collection methods that could be employed :

1. Measurement and verification. We conducted a physical measurements of the incinerator furnace to confirm its actual dimensions (diameter and height) to ensure accuracy in capacity calculation. Use precise measuring tools like calipers, tape measures, or laser distance meters.
2. Prototype testing. We developed a prototype of the incinerator and perform controlled tests to validate the calculated volume capacity. Use materials similar to those intended for incineration and measure the actual volume it accommodates.
3. User survey and feedback. We collected a feedback from users who have used the incinerator. Gather information on the amount and type of waste they typically dispose of and their experience with the incinerator's capacity in handling their waste.
4. Manufacturer specifications and documentation. It’s refer to the technical documentation or specifications provided by the manufacturer to verify and cross-reference the calculated capacity against the intended design specifications.
5. Field observations and case studies. It conducted on-site observations at locations where these incinerators are deployed. Monitor and record the actual volume of waste being incinerated over a specific period to understand real-world usage and compare it against the calculated capacity.
6. Comparative analysis. It compare the calculated capacity against similar incinerator models available in the market. Gather data on their stated capacities and conduct comparative analysis to validate the accuracy of the calculations.
7. Expert consultation. We seek an advice or consultation from experts in the field of incineration technology or engineering to evaluate the methodology used for capacity calculation and gather insights on potential factors that might influence the actual capacity

2.3.2 Data of Combustion Rate

Here are some data collection methods based on the information provided about the portable incinerator device and the measurements :

1. Testing and measurement log. First we maintain a comprehensive logbook during the testing phase, recording the mass of the waste placed into the combustion chamber and the corresponding combustion time for each trial or test run.
2. Sensor integration. Then install sensors or measurement devices within the combustion chamber of the incinerator to automatically track and record the mass of the waste loaded and the time taken for complete combustion.
3. Video recording and analysis. Next step is record video footage during the testing process, focusing on the loading of waste into the incinerator and the duration of combustion. This can be reviewed later for precise measurements and time tracking.
4. Manual observation and timekeeping. Have trained observers manually record the mass of waste added and the time taken for complete combustion during each test. This method may involve using timers or stopwatches.
5. Multiple test runs. We conducted a multiple test runs under varying conditions (different types of waste, varying quantities, etc.) to gather a more comprehensive dataset and assess the consistency of combustion rates.
6. Data Logging Software. Utilize specialized software or applications that enable real-time data logging of the incineration process. This can automatically capture the mass of waste and combustion times, ensuring

The method used in this research is explained in the flow diagram in Figure 2.

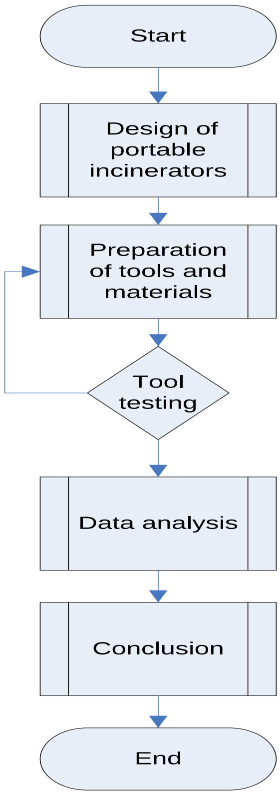

Figure 5. Flow diagram

3. Results and Discussion

Incineration is a waste processing process that involves burning at temperatures above 150°C to reduce combustible waste that cannot be recycled, remove bacteria, viruses and toxic chemicals. A portable incinerator is a tool designed to burn waste [12], both wet and dry waste, including waste produced by Covid-19 patients. Examples of wet waste from Covid-19 patients are leftover food, rice, vegetables, leaves, rotten fruit, while dry waste is plastic waste, food wrappers, masks, gloves, syringes and tissue.

The following is the result of making a portable incinerator as shown in Figure 5.

Figure 6. Portable Incinerator

3.1. Calculation Results of Incinerator Furnace

From the overall design and construction process of this portable incinerator device, the capacity of the incinerator furnace is 380 mm x 590 mm in cylindrical shape, which can be calculated using the formula for a cylinder and the device specifications as follows: Vcyt = π x r^2 x h (3.1) Explanation: π = 3.14 r = radius of the incinerator furnace h = height of the incinerator furnace Vcyt = volume of the incinerator furnace Vcyt = 3.14 x 192 cm x 59 cm Vcyt = 66878.86 cm^3 = 0.066 m^3 Therefore, in this incinerator, the volume of waste that can be placed into the incinerator furnace is 0.066 m^3.

3.2. Calculation of Combustion Rate

During the testing of the portable incinerator device, measurements were taken for the mass of the waste being placed into the combustion chamber and the required combustion time. Based on the measurement results, the mass of the waste was determined to be m grams, and the combustion time was t seconds.

By using the combustion rate formula m/t, the combustion rate of the portable incinerator device can be calculated. The formula m/t represents the mass of the waste (in grams) divided by the combustion time (in seconds). Here are the results of the combustion rate calculation.

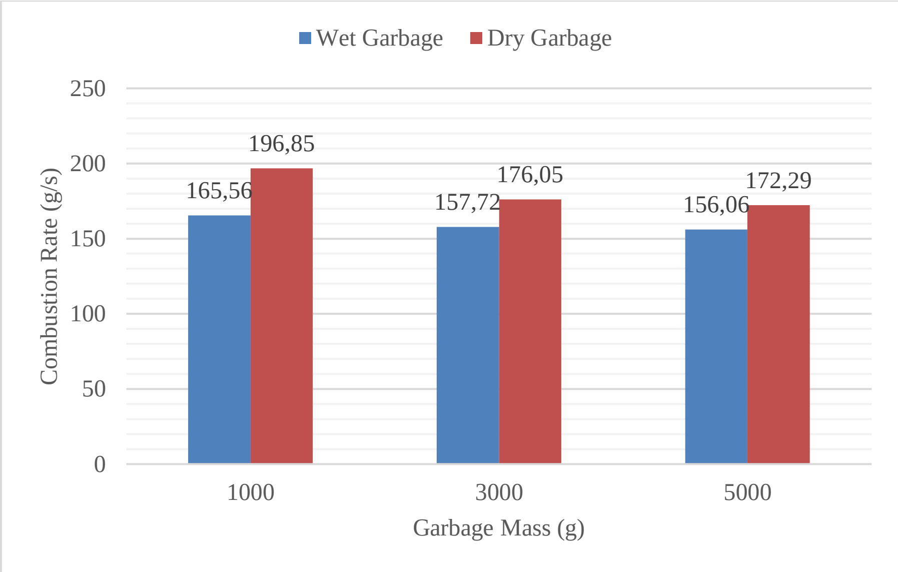

Figure 7. Calculation results of the combustion rate

Based on research conducted, the maximum burning rate of 1000 grams of waste was achieved by dry waste, namely 196.85 g/s. Meanwhile, for waste weighing 3000 grams, the maximum burning rate achieved by dry waste is 176.05 g/s, and for waste weighing 5000 grams, the maximum burning rate achieved by dry waste is 172.29 g/s. This is in line with the results of research [13], where an incinerator fueled by used oil waste was able to burn 12 kg of dry leaf waste in 20 minutes at a burner furnace temperature of 712.30 C and an incinerator combustion chamber temperature of 443.20 C with a fuel consumption of 0. 4 liters. The burning rate obtained from a waste weight of 8 kg is 24.24 kg/hour. As the mass of waste burned increases, the resulting combustion rate decreases. In other words, if the burning rate is low, the waste burning time will be longer. Household scale incinerators that perform well are those that have the fastest combustion rate.

3.3. Calculation of Fuel Consumption

Fuel consumption can be observed based on the combustion time. The longer the combustion time of the incinerator device, the more fuel is required. Conversely, a shorter combustion time requires less fuel. The fuel consumption results for the portable incinerator device can be seen in the following Figure 7.

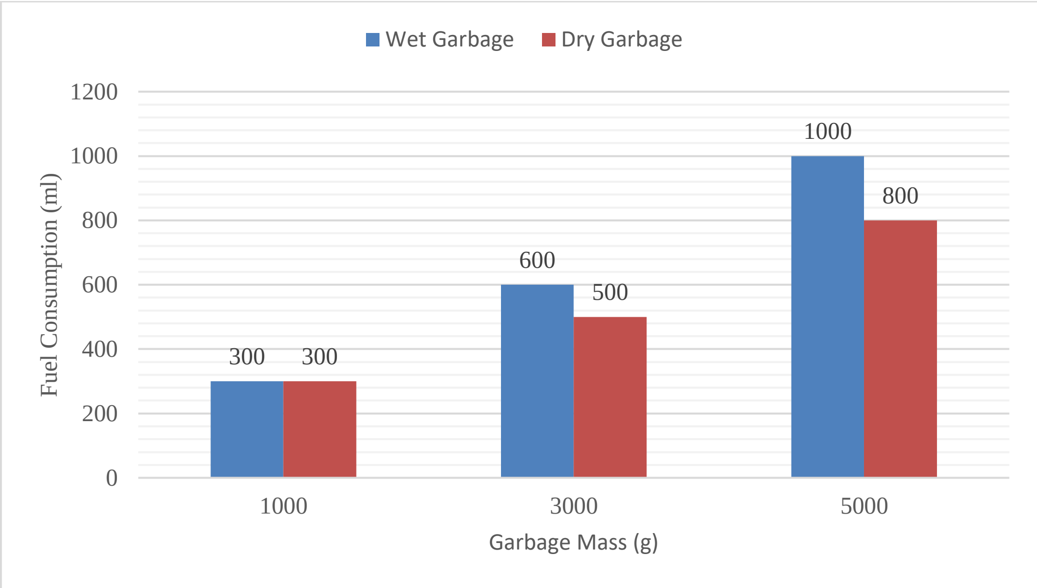

Figure 8. The Fuel Consumption Results

The fuel consumption used in this portable incinerator is minimal when burning 1000 grams of waste, namely 300 ml of used oil. Meanwhile, the highest fuel consumption is obtained from burning 5000 grams of wet waste, which is equivalent to 1000 ml of used oil. This is in line with the results of research [13], where to burn 12 kg of dry leaf waste at a burner furnace temperature of 712.30C and an incinerator combustion chamber temperature of 443.20C it takes 20 minutes with a fuel consumption of 0.4 liters of used oil waste. . The reason is, fuel consumption is determined based on the burning time required for the waste to turn to ash. Dry waste burns quickly and turns to ash, resulting in lower fuel consumption. On the other hand, wet waste requires a longer burning time, causing higher fuel consumption.

4. Conclusion

A portable incinerator with a maximum capacity of 5000 grams of waste has been successfully created. The performance of the portable incinerator is seen from the highest combustion rate for burning 1000 grams of dry waste at 196 g/s, and the lowest for burning 5000 grams of wet waste at 156.06 g/s. The minimum fuel consumption used in this portable incinerator is for burning 1000 grams of waste, namely 300 ml, while the highest fuel consumption is obtained from burning 5000 grams of wet waste at 1000 ml.

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