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Study of the Potential of Refuse Derived Fuel (RDF) at the Cipayung Final Disposal Site (TPA) to Meet Industrial Quality Standards and Environmentally Friendly

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ABSTRACT

The increased demand for energy is impacted by the growing population. As a result, new energy sources must be developed to replace the diminishing supplies. Waste to Energy (WTE) is a concept that can be used as an alternative to recycling waste into raw materials for Refuse Derived Fuel (RDF). Due to their combustibility, inorganic waste and plastic have the potential to be employed as source materials for RDF. In light of this discussion, RDF is required for both domestic and commercial purposes. chosen by classifying the garbage into different sizes and types. In order to demonstrate the huge potential for RDF treatment of active zone waste at the Cipayung Final Disposal Site (TPA), research has been conducted on the potential of RDF that meets industry standards and is environmentally friendly. From the analysis of available data, it is found that without using plastic and rubber waste, the calorific value of the RDF produced meets the required industry standards.

I. Introduction

Garbage is the remains of a material that has undergone processing (most of which have been disposed of and processed) and are no longer of value. From an economic point of view, waste is useless, and from an environmental point of view, waste can cause pollution or disturb the preservation of nature. Waste is material that cannot be used, whether it has been taken as the main component or goods that cannot be used anymore (used products) [1]. Materials that are no longer useful are considered waste from a socio-economic point of view. Garbage is unusable material that is dumped into the environment, where it contributes to various health problems and disruption to environmental sustainability.

In other words, waste is an unwanted by-product that remains after a process. In settlements, waste recycling, both organic and inorganic waste is still a problem that is only the responsibility of the cleaning staff [2]. Through the concept of Refuse Derived Fuel (RDF), this study intends to determine the formation of waste, the characteristics of waste, and the energy potential generated from inorganic waste, especially RDF waste components. The purpose of making RDF is to create fuel from municipal waste that can be burned for both industrial and household purposes [3].

Collection, transfer, processing, recycling and disposal of waste are part of waste management. A waste management activity that tries to reduce its impact on beauty, health and the environment. Between developed and developing countries, and between urban and rural locations, there are differences in waste management strategies. The type of waste material, the land used to

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process it, and the available land area influence the waste management strategy. Reusing waste involves the process of turning it into a commodity with commercial value.

Because of its impact on the environment, waste management in Indonesia is a very crucial issue. The world's attention is currently focused on the waste problem. Indonesia is considered not yet capable of processing waste, and relatively few people are aware of the importance of waste management. In society, this often creates social problems [4].

Refuse Derived Fuel (RDF) is a process of separating high-value calorific value fractions from a Municipal Solid Waste (MSW) separation process. RDF is a fuel made from recycled waste which has a high heat output value [5]. One potential answer to the waste problem is the use of waste as RDF feedstock. Municipal waste can be converted into RDF in a number of steps, including source selection, machine-assisted sorting, cutting to appropriate sizes, re-separation, mixing with various additives, drying, packing, and storage [6].

Based on certain characteristics, waste is divided into many categories, but in general it can be divided into two categories, namely:

a) Organic waste

Waste generated from parts of plants or animals obtained from agricultural, animal husbandry, fishery, or other processes. This waste can decompose quickly through natural processes. The majority of household waste is organic. Various kinds of waste materials are categorized as organic waste, including kitchen scraps, food scraps, vegetable scraps, fruit peels, and leaves.

b) Inorganic waste

Waste generated from industrial processes or non-renewable natural resources such as minerals or oil. Some materials, such as plastic, are materials that do not exist in nature. Inorganic materials are generally materials that are difficult to decompose by nature, or are materials that can only be decomposed in a very long period of time. This type of waste generated at the household level includes bottles, plastic bottles, plastic bags, and cans. Exceptions exist in paper, newspapers, and cardboard. Even though it is included in the category of inorganic waste, it can be easily decomposed in nature or recycled like other inorganic waste.

Waste management is mandated by Law Number 18 of 2008 as a systematic, comprehensive and continuous activity whose implementation involves waste handling and waste reduction. Waste management seeks to turn waste into a resource while improving public health and environmental quality. If the treated waste does not become a breeding ground for germs or a channel for disease transmission, then waste processing is considered successful. Processing is the process of treating waste to reduce or completely eliminate potential environmental problems. Processing waste can be done simply by throwing it away or turning it back into valuable materials (recycling) [1].

Waste is a potential source of energy, as we know that energy is an important component of human existence and life. With technological advances that are getting faster and to support economic growth, energy demand in the industry grows along with this growth. This is especially true for Indonesia, which aspires to become a more developed country. On the other hand, we know that oil will eventually run out as the main energy source that we use today. To meet the increasing energy needs and increasingly stringent environmental demands, we must not only reduce our dependence on energy derived from non-renewable natural resources, but also must seek new alternative energy sources. Such as solar energy, wind, water currents, geothermal energy, and other renewable energy sources, such as biomass energy by changing biological elements such as waste or garbage.

Depok City is an example of a growing big city in Indonesia that has problems with waste management. According to data from the city of Depok, which has a population of around ± 1.8 million people, waste production is increasing every year due to population growth [7]. A total of 3,764 m^3 of waste is disposed of every day in the city of Depok, and is simply thrown away at the Cipayung Final Disposal Site (TPA) [8]. Due to the underutilized potential of waste, research will

be conducted on how to utilize waste as an alternative energy source that is environmentally friendly.

II. Method

By summarizing or characterizing conditions in the field based on data or information in accordance with observational findings, this activity uses descriptive and quantitative methods [9]. Because most of the data received, from data collection to display of results, is in the form of numbers, this observation approach will be more quantitative in nature. Tables are also used to present the results. The Refuse Derived Fuel (RDF) technique in waste management turns waste into usable fuel, thus enabling the processing of waste that is difficult to recycle or if disposed of without processing will contaminate soil conditions [10]. The manufacture of waste that can be used as RDF material is the subject of this research.

III. Results and Discussion

Refuse Derived Fuel (RDF) is the flammable fraction obtained from Municipal Solid Waste (MSW) mixtures given the name "Refuse Derived Fuel" or "RDF" for short. From the world business Council for sustainable development provides defines: "Selected waste and by-products with recoverable calorific value can be used as fuel, partially replacing conventional fossil fuels, such as coal, if they meet strict specifications."

A. Production Process for Making RDF – Pelletizing

Municipal Solid Waste (MSW) is processed through five important steps for the manufacture of Refuse Derived Fuel. The main steps involve pre-separation, sizing, shredding, magnet separation and pelletizing [11]. There are several production processes for making Refuse Derived Fuel (RDF) for use in household and industrial needs, including:

a. Early separation

This process involves separating municipal waste into Bio degradable, glass, cloth, paper, plastic, leather and rubber, metals and other domestic hazardous materials, etc. These forms for the manufacture of RDF main particles involve Bio degradable, Paper, Plastic, Leather and Rubber.

b. Size Screening

Size screening involves separating municipal waste based on particle size and shape. This process helps in comfortable material handling.

c. shredding

Shredding involves the process of breaking large amounts of solid waste into smaller pieces by crushing and cutting. This process converts larger municipal waste particles into smaller particles for easy handling and transportation.

d. Air ballistic fan

Shredded scum contains some wet ingredients. The wet material contains a certain amount of moisture. To remove this moisture, air ballistic fans are used.

e. Magnetic separation

Magnetic separation is a process in which magnetically susceptible materials are extracted from a mixture using magnetic force. This process is useful for separating metal particles from crushed particles. Because metal particles are not suitable for RDF.

f. Pelletizing

After magnetic separation the RDF particles are added with a binder such as calcium hydroxide and then thoroughly mixed. It is then converted into pellets of the required size and shape, usually 30mm capsules.

Use of RDF for Household and Industrial Needs

By selecting a random sample of waste in the Final Disposal Site (TPA) in a population that is not too large, data is collected using the direct random sampling method. To separate the properties of the waste to be used as RDF material, the waste is separated into non-organic waste and organic waste. Important applications of RDF are found in the following areas:

- Cement Kiln.
- RDF power plant.
- Coal-fired power plant.
- Industrial steam/hot boilers.
- Pellet stove (Ref. For household use).

RDF advantages

There are several advantages of RDF, including:

- Garbage is used to generate electricity.
- RDF is an alternative and renewable fuel derived from municipal waste.
- Contains high calorific value compared to parent material.
- RDF emission characteristics are superior to coal with less pollutant emissions such as NOx, SOx, CO and CO2.
- Saves land by using less Final Disposal Site (TPA) area.

Disadvantages of RDF

There are drawbacks to RDF but it doesn't reduce its function/usability.

- Costs associated with pre-processing to recover fuel fractions.
- The unit energy yield (ie, kJ per kg MSW) in the case of RDF is less than the parent MSW.

B. Waste Analysis at the Cipayung Final Disposal Site (TPA).

Based on table 1, a comparison of the composition of waste at Cipayung Final Disposal Site (TPA) is made.

Table 1. Composition of Cipayung Final Disposal Site (TPA)

Trash Type	Percentage
RDF	29.1
Non-RDF	7.24
Organic	62.95
Residue	0.71

Source: [12]

Based on the table above, there are four categories of waste sent to the Cipayung Final Disposal Site (TPA), namely RDF waste, non-RDF waste, organic waste, and residual waste. RDF waste is waste consisting of plastic, wood, rubber, cloth and paper waste which will be used as raw material for Refuse Derived Fuel (RDF). Meanwhile, non-RDF waste, which includes cans, glass, metal, and other materials, is a category of waste that is not used as a source of RDF. Residual waste that can no longer be used is disposed of at the Final Disposal Site (TPA). Meanwhile, food waste and garden waste are considered organic waste.

Organic waste can be used as compost and waste from plastic, rubber, wood, paper and cloth can be used as raw material for RDF. This waste processing can reduce the volume of existing waste by 92.05% (62.95% organic waste + 29.1% RDF waste).

Table 2. Composition of RDF Waste at Cipayung Final Disposal Site (TPA)

Waste Component	Percentage
Plastic	21.36
Rubber	0.5
Paper	6.1
Wood	0.57
Cloth	0.57

Source: [12]

The calorific value of RDF waste at Cipayung Final Disposal Site (TPA) is then calculated using the calorific value of the waste as a reference value.

Table 3. Calorific Value Reference

Waste Component	Calorific Value (MJ/kg)
Plastic	33.49
Rubber	30.14
Paper	15.02
Wood	18.42
Cloth	21.77

Source: [12]

The average daily waste generation at the Cipayung Final Disposal Site (TPA) is 1,100 tons, and the density of RDF waste at Cipayung Final Disposal Site (TPA) is 320,100 kg/day [12].

Table 4. RDF waste generation at Cipayung Final Disposal Site (TPA)

Waste Component	Generation (kg/day)
Plastic	234,960
Rubber	5,500
Paper	67,100
Wood	6,270
Cloth	6,270

Source: [12]

The calorific value obtained from the literature mentioned above will be used as a benchmark for the calorific value expressed in MJ/kg.

Table 5. Potential Calorific Value of RDF Cipayung Final Disposal Site (TPA)

Waste Component	Potential Calorific Value (MJ/day)
Plastic	7,868,810.40
Rubber	165,770.00
Paper	1,007,842.00
Wood	115,493.40
Cloth	136,497,90
Total	9,294,413.70

Processed by: researchers

Table 5 shows the total potential calorific value of Cipayung Final Disposal Site (TPA) of 9,294,413.70 MJ/day. Then the results of calculating the potential content of the calorific value of Cipayung Final Disposal Site (TPA) obtained are:

$$9{,}294{,}413.70 \text{ MJ/day} / 320{,}100 \text{ kg/day} = 29.04 \text{ MJ/kg} \quad (1)$$

The potential calorific value of Cipayung Final Disposal Site (TPA) meets the RDF requirements and is suitable for use as fuel. This can be used as a heating boiler (boiler) in power plants and cement kilns in the industry. Therefore, it can also be used as a pellet stove in the household. In order to potentially be used in industry and households, the calorific value of RDF is adjusted to the provisions in table 6 below.

Table 6. Potential Calorific Value of RDF Cipayung Final Disposal Site (TPA) with RDF Calorific Value of Indocement Ltd

Indocement Ltd calorific value (MJ/kg)	Cipayung Final Disposal Site (TPA) Calorific Value (MJ/kg)
>12.56 (normal)	
12.56-10.47 (moderate)	29.04
<10.47 (low)	

Source: [13]

The table above shows that the heating value of Cipayung Final Disposal Site (TPA) meets the RDF requirements of the industry. Automatically the RDF produced can also be used for household needs as a pallet stove.

Because the content of plastic and rubber produces smoke that is not environmentally friendly in RDF, the percentage of plastic and rubber waste used is 75%, 50%, 25% and 0% with the calculations in Tables 9 and 10 below.

Table 7. Percentage of use of types of plastic waste in calorific value

Indocement Ltd calorific value (MJ/kg)	Percentage Use Kind of trash Plastic	Cipayung Final Disposal Site (TPA) Calorific Value (MJ/kg)
>12.56 (normal)	*100 %*	29.04
	75 %	28.05
	50 %	26.45
	25 %	23.58
	0 %	16.74

Processed by: researchers

Table 8. Percentage of use of types of rubber waste in calorific value

Indocement Ltd calorific value (MJ/kg)	Percentage Use Kind of trash Rubber	Cipayung Final Disposal Site (TPA) Calorific Value (MJ/kg)
>12.56 (normal)	*100 %*	16.74
	75 %	16.52
	50 %	16.30
	25 %	16.06
	0 %	15.82

Processed by: researchers

The table above shows that the calorific value of RDF waste at Cipayung Final Disposal Site (TPA) without using the type of plastic waste (0%) and also the type of rubber waste (0%) still meets the RDF requirements of the industry. That way, the use of RDF type of waste at Cipayung Final Disposal Site (TPA) cannot use plastic and rubber types of waste so that the use of RDF is more environmentally friendly. To maximize the waste processing, this type of plastic waste can be processed into pyrolysis fuel.

To be able to glue the RDF materials, an adhesive is needed, and 5% tapioca flour is used in the RDF material used [14]. Then the adhesive materials needed for each RDF material at the Cipayung Final Disposal Site (TPA) every day are:

$$5\% \text{ X } 79.640 \text{ kg} = 3.982 \text{ kg} \quad (2)$$

From the calculation above, 3,982 kg of tapioca flour is needed for RDF adhesive material from RDF waste at Cipayung Final Disposal Site (TPA) every day.

IV. Conclusion

Refuse Derived Fuel (RDF) is considered as one of the green fuels and leads to a green environment. This can partially solve the existing problems with municipal waste and energy requirements. Many benefits are realized both in terms of economics and in terms of health. The waste problem is not only a problem for the government, but also a problem for the community. Some of the energy needs of households and industries in the future can be met from the RDF produced by the existing TPA.

Separation of various types of waste between organic waste from households and waste that can be processed into RDF will make it easier to convert waste into fuel (RDF). Industrial waste,

wood waste, and plastic waste can be used to make RDF fuel with a high calorific value that meets industry standards.

The potential for waste at the Cipayung Final Disposal Site (TPA) can produce RDF with a calorific value of 29.04 MJ/kg, or the equivalent of 9,294,413 MJ/day. To get an environmentally friendly RDF, a calculation is made using the percentage of plastic waste (0%) and rubber waste (0%). And the results obtained were 15.82 MJ/kg which still met the industry's RDF requirements (12.56 MJ/kg). So that the potential for environmentally friendly RDF at the Cipayung TPA is 79,640.00 kg/day, energy of 9,294,413 MJ/day will be obtained.

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