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PROSPECTS OF WASTE TO ENERGY FROM CONTROLLED LANDFILL SYSTEM IN CIREBON, WEST JAVA

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ABSTRACT

This research aimed to examine the potential of waste from controlled landfills a raw material for a Waste-to-Energy (WtE) plant. The research employed the qualitative method with direct observation. Data were analyzed descriptively. The results showed that the composition of waste in Cirebon was mostly dominated by household food waste (52.41%), followed by plastic (15.58%) and paper (8.05%). Based on the amount of existing waste and the projected amount in Cirebon City and Cirebon Regency, the waste can potentially be used as raw material for WtE plant. The energy generated from this waste can be sold to PLN, creating a positive utilization of the waste. It is projected that Cirebon City will produce 1319 m^3/day of waste, and Cirebon Regency will produce 4767.65 m^3/day (1161.26 tons/day) in 2023. Therefore, further research is needed to develop appropriate, efficient, and environmentally friendly technology for the municipal solid waste management system in Cirebon.

Keywords : waste management; controlled landfill; waste-to-energy (WtE) plant; Cirebon

INTRODUCTION

The use of plastic as the primary material for various products is not a new innovation. According to a report from the World Bank, the global volume of solid waste has reached 1.3 billion tons per year, and the amount of plastic waste and other solid waste continues to increase by 70%. This volume is estimated to reach 2.3 billion tons by 2025 (Hoornweg et al., 2013). Indonesia is the second-largest contributor to plastic waste in the world, after China, producing 187.2 million tons of plastic waste(Jambeck et al., 2015). Moreover, many of Indonesia's large rivers are ranked among the world's top 20 most polluted rivers due to plastic waste (Laurent & Owsianiak, 2017).

Garbage is a solid by product of human activity and is predominantly found in urban areas, including the Cirebon region. The types of waste found in the Cirebon area include plastic waste, cans, as well as vegetable and fruit residues from markets (Puspitawati, 2012). According to data from the National Waste Management Information System, as of 2020, Cirebon Regency produces a daily waste generation of 1308.06 tons/day, with an annual total of 477,442.72 tons/day (https://sipsn.menlhk.go.id). Meanwhile, the waste managed by the waste handling department of the local government in Cirebon Regency is 89 tons/day (7.4% of the waste), and community-based waste reduction efforts such as waste banks manage 18 tons/day (1.5% reduction). Most of waste management in the Cirebon area is conventional, involving collection, transportation, and disposal systems, including open dumping sites. Unfortunately, these final disposal sites often have an adverse impact on the environment, creating an unpleasant sight, producing foul odors, and posing a continuous threat to public health (Gede & Partha, 2010).

Until now, waste management in Cirebon has not been effectively managed due to several factors, including the high amount of waste produced, low levels of waste management services, the limited number of final waste disposal sites, ineffective waste management institutions, and high costs. Moreover, the establishment of final disposal sites with open dumping systems in several areas has exacerbated these problems and posed a significant threat to public health and the sustainability of environmental ecosystems.

One possible solution to address these waste management problems is to implement a waste-to-energy system using controlled landfill. The controlled landfill method involves compacting and covering waste with topsoil at least every seven days, making it an intermediate option between open dumps and sanitary landfills. This method not only offers lower investment and operational costs but also reduces the environmental impact of waste management (Meidiana & Gamse, 2011), allows for land reuse after waste disposal, and improves environmental aesthetics (Vanapalli et al., 2019). However, the implementation of controlled landfill systems in waste management remains limited in the West Java region, particularly in Cirebon, making further research in this area necessary.

METHOD

This research employed the qualitative method with direct observation. In data collection, fieldwork and interviews were employed to obtain primary data from the key informants in the final waste management; secondary data were obtained from an analysis of documents. Surveys and observations were conducted at temporary waste shelter final disposal sites located in Cirebon, Kuningan Regency, Majalengka Regency, and Indramayu Regency. The field data were in the form of primary data obtained directly from the source or the first party and secondary data were obtained from the existing data. The required data comprised 1) waste volume data and their monthly and annual projections, 2) types, sources, and compositions of the disposed waste at the research site, and 3) Waste generation projection in Cirebon. The data were descriptively analyzed.

RESULTS AND DISCUSSIONS

The potential waste generation in Cirebon Regency is 1,198 tons per day. However, the waste currently managed by the Government of Cirebon Regency's waste handling service is only 89 tons per day (7.4% of total waste), while the community-based waste reduction efforts handle 18 tons per day (1.5% of total waste). The solid waste service at the regional level covers 27 out of 40 sub-districts in Cirebon Regency. However, the majority of waste management in the area still follows a conventional approach, involving the collection, transportation, and disposal of waste via landfills or open dumping. The steps of this research are as follows:

a) Garbage was collected based on its origin. Waste from the community (housing) was collected independently, while waste from the market was collected by market managers for village markets. Finally, garbage from the local government market and litter on the road were collected by sweepers from the Department of the Environment.

b) The waste that had been collected was then transported to the nearest temporary waste shelter (TPS).

c) The garbage from the TPS (Transfer Station) was regularly transported to final disposal sites using garbage trucks for routes passing through main roads in cities, and tricycles for smaller streets or alleys that were inaccessible by trucks.

d) The waste transported to the temporary and final waste shelter was managed in a controlled landfill. The waste that accumulated at the final disposal site was leveled and regularly sprayed (every 3 days) to minimize the odors generated by the waste. Finally, the accumulated waste was covered with soil periodically, at least once a week.

Figure 1. Waste Condition in the Final Waste Management, Cirebon A) TPA Gunung Santri; B) TPA Kopiluhur

The controlled landfill system at TPA Kopi Luhur is designed to improve waste disposal methods by establishing facilities for environmental protection. The waste is spread and compacted to a thickness of 2.5 meters, then covered with daily soil cover every 7 days. When the thickness of the waste reaches 5 meters, it is covered with soil cover 30 centimeters thick. This process is repeated until the maximum height of 15 meters is reached, and the landfill's useful life is estimated to be 6.6 years (Isni et al., 2020).

Observations have revealed that the largest sources of waste are household waste and traditional market waste, particularly food waste. The highest waste composition is from plastic, paper, leather, and rubber, while glass waste requires special handling. Waste composition varies widely in various sectors, including agriculture, household food, human, and animal waste. The data indicate that household food waste dominates the waste stream (52.41%), followed by plastics (15.58%) and paper (8.05%) (Figure 2).

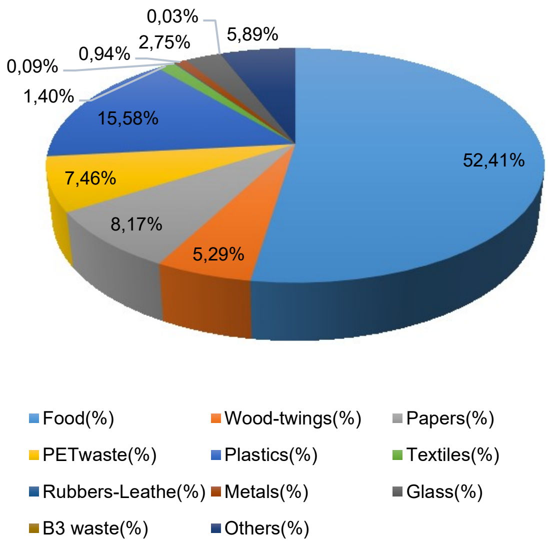

Figure 2. Waste Composition in Cirebon, West Java

The role of community households in the urban waste management system in

Cirebon Regency is a crucial aspect. Market waste typically comprises organic waste, such as vegetable residue, and wet food, including vegetables, wet fish, and side dishes that spoil easily if not transported promptly (Table 1).

Observations have revealed that the majority of market waste in the Cirebon area is organic waste, primarily leftover vegetables and easily perishable side dishes. The number of market waste processing facilities is still limited, and in some areas, waste is simply piled up without proper processing. It is urgently necessary to implement a combination of prevention strategies and waste recycling. The main focus should be on prevention strategies to mitigate climate change, while emphasis should also be placed on recycling waste for future energy production. Decision-makers should take appropriate steps to ensure environmentally friendly waste management.

Table 1. Traditional Markets in Cirebon

No	Market Names	Addresses
1	Pasar Harjamukti	Jenderal Sudirman Street, North Penggung Cirebon
2	Pasar Jagasatru	Jagasatru street, Cirebon
3	Pasar Pagi	Siliwanggi street, Cirebon
4	Pasar Drajat	Pangeran Drajat street, Cirebon
5	Pasar Kramat	Siliwangi-Kramat street, Cirebon
6	Pasar Kanoman	Winaon street No. 1, Cirebon
7	Pasar Perumnas	Ciremai Raya street, Cirebon
8	Pasar Buah	Kalitanjung street, Cirebon.

Waste management plays a vital role in reducing the greenhouse effect and has the potential to be utilized as a renewable energy source. Based on the amount of existing waste and projected waste generation in Cirebon City and Cirebon Regency, waste has significant potential to be used as a raw material for a Waste-to-Energy (WtE) plant. The energy produced can be sold to PLN, and the leftover waste can be positively utilized. The projected amount of waste in Cirebon City for 2023 is 1319 m^3/day, while in Cirebon Regency, it is 4767.65 m^3/day (1161.26 tons/day) (Figure 3). The generation of WtE offers numerous social benefits, such as improved public health, odor reduction, waste reduction, and the presence of renewable energy that benefits local communities. It also provides economic benefits, including the creation of new jobs and the improvement of the local economy. Additionally, WtE offers environmental benefits, such as reduced air and odor pollution and a reduction in the use of fossil fuels (Khan et al., 2022; Khan & Kabir, 2020). However, to ensure that all these benefits are realized, the selection of the appropriate technology is a crucial prerequisite and requires a pre-assessment study.

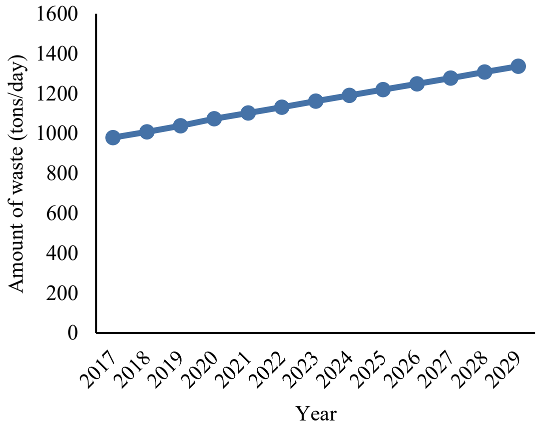

Figure 3. Waste Generation Projection in Cirebon

In recent years, as the demand for alternative energy sources has increased, a number of Waste to Energy (WtE) technologies have been explored for energy production. Generally, there are two types of technologies that can be applied to convert waste into energy: thermal and chemical conversion. Thermal conversion includes processes such as incineration, gasification, and pyrolysis, while chemical conversion includes landfill gas generation (Cucchiella et al., 2017; Dong et al., 2018; Evangelisti et al., 2015; Khan et al., 2022; Mubeen & Buekens, 2019). In addition to thermal and chemical conversion technologies, there are also waste to energy technologies that use biochemical processes, such as fermentation, anaerobic digestion, landfill with gas capture, and microbial fuel cells. There are also emerging technologies, such as hydrothermal carbonization and dendro liquid energy, that have potential for waste to energy conversion (Istrate et al., 2020; Mubeen & Buekens, 2019). Indonesia has implemented waste processing technology in various regions, including in Surabaya. The final disposal site in this city receives 1500 tons of waste per day. The majority of the waste accumulated at the final disposal sites is processed into electrical energy. With the Landfill Gas Collection technology, 1000 tons of waste daily produces 2 Megawatts of electrical energy, while the Gasification Power Plant technology generates 12 Megawatts of electrical energy (Sucahyo & Fanida, 2021). Additionally, the Waste Power Plant tested in the city of Padang has shown promising results. The gas produced at the TPA Air Dingin Padang City can generate 3215.67 kW of electrical power, resulting in a total of 28,169,259.47 kWh of electrical energy (Dodi et al., 2015). The potential of utilizing waste as a raw material for the Waste Power Plant in Pekanbaru City is estimated to be 9 MW, making it a viable alternative source of renewable energy. Of this energy, 8 MW can be sold to PLN, making it possible to repurpose unused waste (Monice & Perinov, 2017).

CONCLUSION

This study concludes that proper management of waste in the Cirebon area can potentially generate electricity through the Controlled Landfill System. Effective waste management requires collaboration from various stakeholders, and thus it is important to establish good cooperation to implement this program. More research is needed to identify appropriate, efficient, and environmentally friendly technologies for municipal solid waste management in Cirebon.

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