p-ISSN 2579-9150; e-ISSN 2579-9207, Volume 3, Number 1, page 28 - 46, October 2019
Accredited SINTA 2 by Ministry of Research, Technology, and Higher Education of The Republic of Indonesia No. 23/E/KPT/2019 on August 8th, 2019 from October 1st, 2018 to September 30th, 2023

Indonesian Journal of Urban and Environmental Technology
http://www.trijurnal.lemlit.trisakti.ac.id/index.php/urbanenvirotech

MATERIAL FLOW ANALYSIS OF WASTE BANK ACTIVITIES IN INDONESIA: CASE STUDY OF MEDAN CITY

Hafizhul Khair[1, 2*], Iga Yusmaidah Siregar[2], Indriyani Rachman[1], Toru Matsumoto[1]

[1]Graduate Programs in Environmental Systems, Graduate School of Environmental Engineering, The University of Kitakyushu, Kitakyushu, Japan
[2]Department of Environmental Engineering, Faculty of Engineering, Universitas Sumatera Utara, Medan, Indonesia

*Corresponding author: hafizhul@usu.ac.id

ABSTRACT

Aims: This study aims to improve waste bank activities in Medan and make them more efficient **Methodology and Results:** The study involved the collection of secondary and primary data. The secondary data collected involved a general description of the study area, number, status, and location of the waste bank. Primary data included interviews and field research on selected waste banks. Importantly, survey and data collection were conducted from December 2017 to April 2018. A semi-structured interview survey approach was conducted to collect the data. Using the Material Flow Analysis (MFA) methodology, the findings of the study showed that of the total amount of the input material, 87.4 % is a recyclable waste and 12.6 % water. Also, the waste bank activities generate 87.2% recyclable items, 12.6% wastewater, and 0.2% residues. **Conclusion, significance, and impact study:** The findings are essential in understanding the use of resources to provide information for improving waste bank activities and waste management. Apart from the community, the government also plays a significant role in supporting the future of waste banks. This study found that waste bank activities are still conventional, with no technology adoption. In the future, the waste bank should be more efficient and manage large amounts of wastes, because the potential for recyclable products is still abundant.

MANUSCRIPT HISTORY

- Received September 2019
- Revised October 2019
- Accepted October 2019
- Available online October 2019

KEYWORDS

- Material flow analysis
- Waste bank
- Waste management

p-ISSN 2579-9150; e-ISSN 2579-9207, Volume 3, Number 1, page 28 - 46, October 2019
Accredited SINTA 2 by Ministry of Research, Technology, and Higher Education of The Republic of Indonesia No. 23/E/KPT/2019 on August 8th, 2019 from October 1st, 2018 to September 30th, 2023

1. INTRODUCTION

Waste management has increasingly become a complex problem to be resolved and requires a long process, especially in Indonesia. Indonesia's Law 18/2008 on Waste Management stated the need for a fundamental paradigm change in waste management. Changes include in the paradigm of collect - transport - dispose of processing that relies on reducing waste and handling the waste. All levels of society, both government, business, and the wider community, carry out activities to reduce waste generation, recycle and reuse the waste or known as Reduce, Reuse and Recycle (3R) (KLH, 2013). The government has set a target in the form of a National Strategy Policy on Waste Management, which sets 30% reduction and 70% handling activities in 2025 (KLHK, 2018). In 2017, the achievement of reducing household waste had only reached 2.12 percent. This figure is far below 15 percent which has been targeted by the Presidential Regulation number 97/2017 concerning National Policies and Strategies for Household Waste Management and Household Waste (Susanto and Adi, 2018).

The waste bank or "*bank sampah*" is a concept of waste management in Indonesia the handling of recyclable waste and enables people to earn money in the form of savings by depositing their recyclable wastes in the waste bank. Waste banks are set up in neighborhoods typically for about 1000 residents and are usually run by poorer people who wish to increase their income (Temesi Recycling, 2019). At waste banks, the waste created by the household is divided into two categories - organic and non-organic. Organic waste gets turned into compost, while non-organic waste is divided further into three categories: plastic, paper, plus bottles and metal. Periodically, households make deposits with their non-organic solid waste, which are weighed and given a monetary value, based on rates set by waste collectors. This value is saved in their waste account from which, like a regular bank, they can withdraw. The basic principles of waste banks remain the same across provinces: collect, save, earn, change behavior, and enjoy a clean neighborhood (Salim, 2013). Most waste bank programs are easy to find in South East Asia countries. An example is in Thailand, family members of waste banks could get funeral-assistance as an incentive of the program (Challcharoenwattana and Pharino, 2015).

Waste bank program raised awareness of the importance of recycling (Alias *et al.*, 2019). The waste bank also encourages people to participate in management of their surround environment actively. The operation of waste banks usually relies on the participation of the community where the waste bank is located and on the cooperation of the recycling sector (Priyo *et al.*, 2018). The

p-ISSN 2579-9150; e-ISSN 2579-9207, Volume 3, Number 1, page 28 - 46, October 2019
Accredited SINTA 2 by Ministry of Research, Technology, and Higher Education of The Republic of Indonesia No. 23/E/KPT/2019 on August 8th, 2019 from October 1st, 2018 to September 30th, 2023

waste bank activity is believed to be able to solve the environmental issue as a part of waste management and reduce the amount of waste dumped into landfills and provide economic benefits to the community (Wijayanti and Suryani, 2015). Integrating the waste bank program into municipal solid waste management is predicted decrease greenhouse gas emissions (Raharjo *et al.*, 2017). The integration is not limited to environmental approaches, but also social and economic approaches (Satori *et al.*, 2018). When the amount of waste to landfill is reduced, the operational costs of waste management can be cut. Waste bank activity is not only benefiting from the economic side, the empowerment of the local economy but also in terms of environmental and social issues (Wulandari *et al.,* 2017). In order to improve the community activity in 3R, the collaboration between the government and community, private sector, and NGOs have to be conducted (Dhokhikah *et al.,* 2015).

Indonesia issued a regulation specifically regulating waste banks activity, a Ministry of Environment Regulation No. 13 2012 to implement of Reduce, Reuse, and Recycle (3R) concept through waste banks. In 2012, there were approximately 886 waste banks in Indonesia (KLH, 2013; Widyarsana and Salmaa, 2019). The number of waste banks increased to 1172 in 2015 (Putri, 2018). In 2018, the number of waste banks grew significantly to 5,244 units across 34 provinces and 219 regencies/cities in Indonesia. Waste banks contribute 1.7% of the national waste reduction (1,389,522 tons/year) from the national waste generation and generate an average income of Rp. 1,484,669,825 per year (KLHK, 2018). Participants of the waste banks are dominated by the community from lower education and income. They participate in waste bank programs to increase their income (Maryati *et al.,* 2018).

Medan is the capital city of North Sumatra province, with more than 2.3 million inhabitants. The city has an area of about 265.1 sq.km. Located near the equator, the northern part of Sumatra Island, Indonesia, Medan has a tropical climate with two major seasons; dry season (February - July) and the rainy season (August - January) (Statistic of Medan Municipality, 2017).

Medan generates household wastes (HWs) at an average of 0.222 kg/person/day. This amount contributes to one-third of the amount of waste disposed to the landfill every day. Most of them are compostable wastes, as much as 61.35%, followed by 28.70% recyclable waste (Khair *et al.,* 2019). The sanitation agency in 2016 estimated that as much as 1,600 tonnes of waste from various sources were disposed into the landfill every day, while in 2017, the number waste dumped to landfill increased to 2000 tonne/day (Naipospos, 2017).

p-ISSN 2579-9150; e-ISSN 2579-9207, Volume 3, Number 1, page 28 - 46, October 2019
Accredited SINTA 2 by Ministry of Research, Technology, and Higher Education of The Republic of Indonesia No. 23/E/KPT/2019 on August 8th, 2019 from October 1st, 2018 to September 30th, 2023

Formally, there is no sorting at the source or the communal container. The mixed waste is directly disposed to the landfill. Informal parties such as scavengers (waste pickers) try to find items of economic value that are then sold to collectors. Waste in Medan City is disposed to the Terjun landfill, which is managed by the municipality, and located in Medan Marelan sub-district, approximately 15 km from the city center. At Terjun landfill, there is also no waste processing; the waste is just dumped without treatment. Scavengers are involved in the collection of recyclable items here.

For this research, material flow analysis (MFA) has been chosen as a practical decision-support tool in resource management, waste management, and environmental management. MFA is a valuable tool in substance management because it can cost-efficiently determine the elemental composition of waste precisely. Some experts who have experience with MFA suggest that waste management should be replaced by materials and resource management (Brunner and Rechberger, 2016).

In Jakarta, a study used MFA to propose alternative solutions to improve plastic waste management (Putri *et al.,* 2018). MFA could contribute a better sight of waste flow in waste bank activities and identify the process and flow that have the highest potential for improvement and more efficient. MFA widely used as a tool in waste management at many sectors, for example in quantifying the e-waste flow (Islam and Huda, 2019), examining food loss rate (Ju *et al.,* 2017), recycling potential of plastic waste (Faraca and Astrup, 2019), paper waste (Van Ewijk *et al.,* 2018) and also in construction waste (Condeixa *et al.,* 2017).

Thus, this study aims to improve waste bank activities to be more efficient. The objective of this study is using the material flow analysis to investigate waste bank activities in Medan, Indonesia, in order to support the decision making process of waste management stakeholders.

2. RESEARCH METHODOLOGY

2.1 Overview of Waste Bank

As in many other cities in Indonesia, the waste bank activities in Medan have not been integrated as a formal sector into the waste management system. Most of the waste banks in Medan City are managed by the community, organizations, and individuals. They provide services for exchanging recyclable items into money in a savings system that adopts a simple version of the bank's formal system and uses temporary places owned by individuals or organizations. In

p-ISSN 2579-9150; e-ISSN 2579-9207, Volume 3, Number 1, page 28 - 46, October 2019
Accredited SINTA 2 by Ministry of Research, Technology, and Higher Education of The Republic of Indonesia No. 23/E/KPT/2019 on August 8th, 2019 from October 1st, 2018 to September 30th, 2023

general, recyclable items received from the community are weighed and recorded in the savings book, and the amount of equivalent money of the item will be paid once every three months or more.

According to records from Dinas Lingkungan Hidup Kota Medan (2017), shows there were 97 active of 142 registered waste banks in Medan. Based on 97 units of active waste banks, only 13 waste banks were fit for a "good" rating, and the rest were below until 2017.

2.2 Methodology and Data Collection

The study of waste bank activities was conducted in Medan city. The stages of this study include the collection of secondary data and primary data. Secondary data collected is a general description of the study area, number, status, and location of the waste bank. Primary data in this study were interviews and field research on selected waste banks. The survey and data collection were conducted in December 2017 until April 2018. This study used data reports of the waste banks. Since the data report was recorded, it cannot consider the accuracy of the data. A semi-structured interview approach was conducted to cover the following points:

- Background information and waste bank profile
- Information related to necessary activities and processes
- Type of waste that were accepted by the waste banks
- The use of materials and substances
- Input and output through the waste bank processes

In this study, waste banks were sorted according to their rating for each group. Waste banks with the best rating were chosen as the selected waste bank study unit. They consist of one representative from the institution entity, one representative from a school entity and one representative from a community entity. The selected waste bank representing the group is the Sicanang as a representative of the institutional waste bank, *PAUD Fitri* representing the school waste bank and *Membawa Berkah* representing the community waste bank. Table presents the list of the name of the selected waste bank.

p-ISSN 2579-9150; e-ISSN 2579-9207, Volume 3, Number 1, page 28 - 46, October 2019
Accredited SINTA 2 by Ministry of Research, Technology, and Higher Education of The Republic of Indonesia No. 23/E/KPT/2019 on August 8th, 2019 from October 1st, 2018 to September 30th, 2023

Table 1 List of waste bank representatives

No	Type	Name of waste bank	Status	Active members
1	Institution	Sicanang	Active	813
2	School	*PAUD Fitri*	Active	80
3	Community	*Membawa Berkah*	Active	90

This study chose three types of waste banks, the central waste bank Sicanang, *PAUD Fitri*, and *Membawa Berkah*. This study found that *PAUD Fitri* and *Membawa Berkah* include as a partner of the central waste bank. Figure 1 presents the networking of waste banks in Medan.

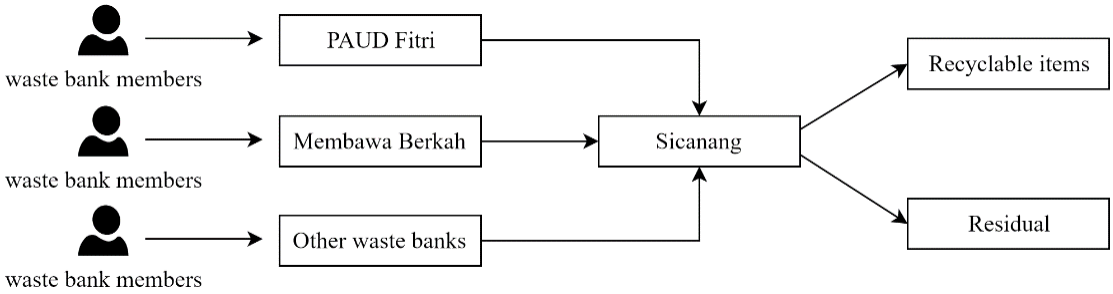

Figure 1 Waste bank networks in Medan

This study used MFA methodology that consists of the following steps (Brunner and Rechberger, 2016):

- Defining the object and goal of the study.
- Determining relevant substance and system boundaries, processes and goods
- Defining flows of good and substance
- Balancing the inputs, outputs, and stock through the processes
- Providing schematic and interpretation results

Several studies used MFA as a tool in on waste management by quantification of waste flows and waste substance. MFA assesses the flows and stocks of materials in a system defined on a spatial and temporal scale (Brunner and Rechberger, 2016). According to the mass balance principle, the mass of all input a process equals the mass of all outputs of this process plus storage. Technically, this can be illustrated through Eq. 1 (Brunner and Rechberger, 2016).

$$\sum_{k_1} \dot{m}_{input} = \sum_{k_0} \dot{m}_{output} + \dot{m}_{storage} \quad (1)$$

Where k_1 and k_0 represent input and output flows respectively and $\dot{m}$ represents the flow or flux. The MFA was started by receiving waste from the waste bank, and it ends at output material from waste bank activities, as shown in Figure 2. The MFA was calculated and modeled using STAN software based on waste bank data in the period of October - December 2017.

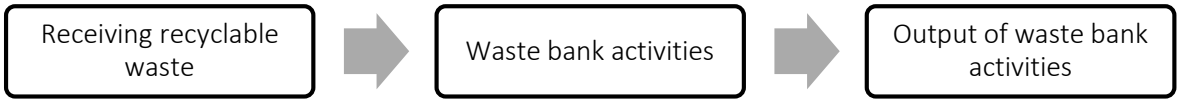

Figure 2 Boundary of study

3. RESULTS AND DISCUSSION

3.1 *PAUD Fitri* Waste Bank

PAUD Fitri waste bank is a Fitri School of Early Childhood Education and Development (PAUD), located on Jalan Lingkungan IV, Lorong Mesjid, Bagan Deli Village, Medan Belawan District, Medan. It accepts payment of school fees with recyclable waste. This goal is to help low-income families in fishing settlements who want their children to go to school. This waste bank was established in 2013, the presence of this waste bank encourages its member (parents of students) collect recyclable waste every day, then bring the waste to school as a substitute for their children's school fees. Besides that, it helps to maintain environmental cleanliness in Kelurahan Bagan Deli and reduces waste disposal in the landfill.

PAUD Fitri members bring the recyclable waste to the waste bank; a staff will weigh the waste and record it. The collected waste from the members will be sorted manually before being transported and sold to Sicanang waste bank. The flow of *PAUD Fitri* activities is shown in Figure 3.

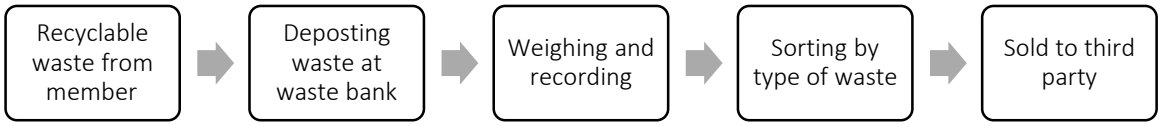

Figure 3 Waste bank activities flow

The types of waste received by *PAUD Fitri* are plastic, paper, glass, and metal waste. *PAUD Fitri* received an average of 658.2 kg recyclable waste every month from its customer. A staff of *PAUD Fitri* is responsible for sorting the waste once a week.

Figure 4 shows the analysis of the material flows of *PAUD Fitri* waste bank. It can be described that there is no significant difference between the input and output. *PAUD Fitri* generates an average of 7 kg residual per month. This residual comes from the cleaning and sorting process of plastic waste. The dominant plastic waste is PET bottle, *PAUD Fitri* remove the PET bottle label and caps in order to increase the price 200 kg of water was used to wash the plastic waste every month, it means 1.05 kg water is needed to clean 1 kg plastic.

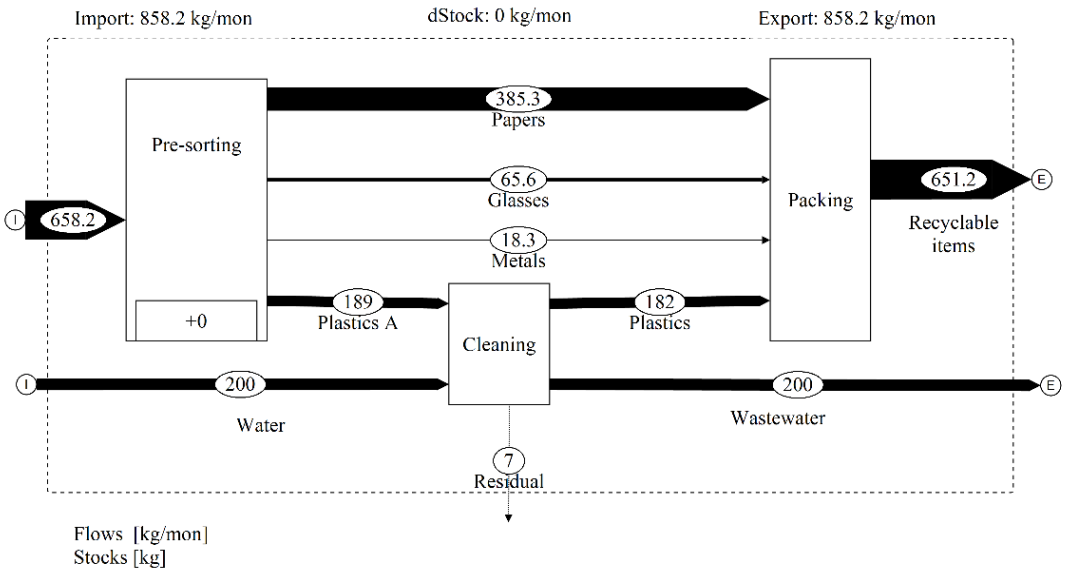

Figure 4 Material flow analysis of *PAUD Fitri* waste bank

3.2 *Membawa Berkah* Waste Bank

Membawa Berkah waste bank was established in 2016. The establishment of this waste bank aims to educate the people against littering; a clean-living environment makes children play

p-ISSN 2579-9150; e-ISSN 2579-9207, Volume 3, Number 1, page 28 - 46, October 2019
Accredited SINTA 2 by Ministry of Research, Technology, and Higher Education of The Republic of Indonesia No. 23/E/KPT/2019 on August 8th, 2019 from October 1st, 2018 to September 30th, 2023

comfortably. In 2017, *Membawa Berkah* waste bank won the award as one of the ten best waste banks in the Gold category in Medan. This waste bank operates once a week, during 2017 *Membawa Berkah* succeeded in collecting ± 20 tonnes of recyclable waste. *Membawa Berkah* obtains the recyclable waste from the community. The waste is sorted and cleaned before being picked up by the third party, currently Sicanang waste bank. The flow of *Membawa Berkah* waste bank is similar to *PAUD Fitri* waste bank, as shown in Figure 5.

Membawa Berkah accepts four types of waste; plastics, papers, glasses, and metals. The average amount of recyclable waste received by *Membawa Berkah* reached 786.52 kg per month. Two workers are responsible for sorting and cleaning the waste with working hours of 12 hours in a month. *Membawa Berkah* requires 280 kg of water per month to clean the waste and discharges 280 kg of wastewater, it equals to 1.18 kg water per kg plastic. From its process, *Membawa Berkah* waste bank generates 2.73 kg of residue per month originated in cleaning the plastic waste in the form of PET bottle labels. Figure 5 shows the MFA of *Membawa Berkah* waste bank.

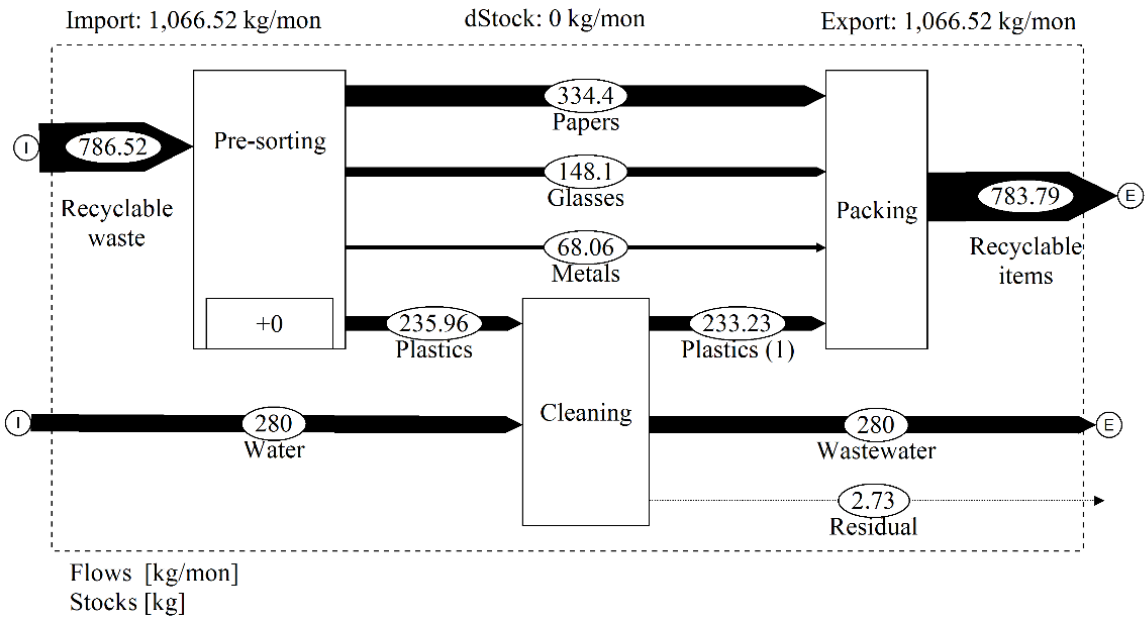

Figure 5 Material flow analysis of *Membawa Berkah* waste bank

p-ISSN 2579-9150; e-ISSN 2579-9207, Volume 3, Number 1, page 28 - 46, October 2019
Accredited SINTA 2 by Ministry of Research, Technology, and Higher Education of The Republic of Indonesia No. 23/E/KPT/2019 on August 8th, 2019 from October 1st, 2018 to September 30th, 2023

3.3 Sicanang Waste Bank

Sicanang waste bank inaugurated by the Mayor of Medan on December 8, 2014. This waste bank aims to carry out waste management activities around the city of Medan as a pilot project for efficient waste management by involving the participation of the community and the City Government. The goal of this collaboration is to reduce the generation of waste disposed to the landfill.

Sicanang waste bank serves pickup and purchase of recyclable waste from other waste banks around Medan City. They will pick the waste up every day from Monday to Saturday. Currently, as many as 60 waste banks have become a partner at the Sicanang waste bank. They deposited the recyclable waste regularly. At this central waste bank, advanced sorting is needed to classify the type of waste into more specific to increase the selling price.

Sicanang waste bank receives four types of waste and export 19 types of waste. Four types of waste received are papers, plastics, metals, and glasses. In advanced sorting, the paper's waste will be sorted into HVS, Duplex, Cardboard, Book, Newspaper, and other papers. Plastic wastes are sorted into HDPE, LDPE, PP, PP (plastic), PET bottle, PET (other), and PS. Metals are sorted into copper, brass, aluminum, cans, and other metal.

Figure 6 Removing the label of mineral water cups

p-ISSN 2579-9150; e-ISSN 2579-9207, Volume 3, Number 1, page 28 - 46, October 2019
Accredited SINTA 2 by Ministry of Research, Technology, and Higher Education of The Republic of Indonesia No. 23/E/KPT/2019 on August 8th, 2019 from October 1st, 2018 to September 30th, 2023

Figure 7 presents the analysis of the material flow of Sicanang waste bank. An example process from Sicanang is plastic wastes. Most of the plastic waste comes as plastic bags; the waste bank sorts the plastic bags based on its color, size, and cuts it into sheets. The next step is to clean the plastic from polluter by washing and drying it. Sicanang waste bank does the waste sorting every day; four workers are responsible for the work. Of the four workers, a person is responsible for sorting paper, a person for sorting metal, and two people for sorting plastic. Although Sicanang receives sorted recyclable waste from its partners, residues are still found. The sorting activities, such as on paper and plastic-type, remain the residues that to be disposed of in landfills. On average, Sicanang waste bank received an average 8,898.03 kg of sorted recyclable wastes per month. Especially for plastic sorting, Sicanang uses and discharges as much as 800 kg of water per month or estimated 0.59 kg water per kg plastic. For the entire process, the waste bank generates 14.5 kg of residue per month.

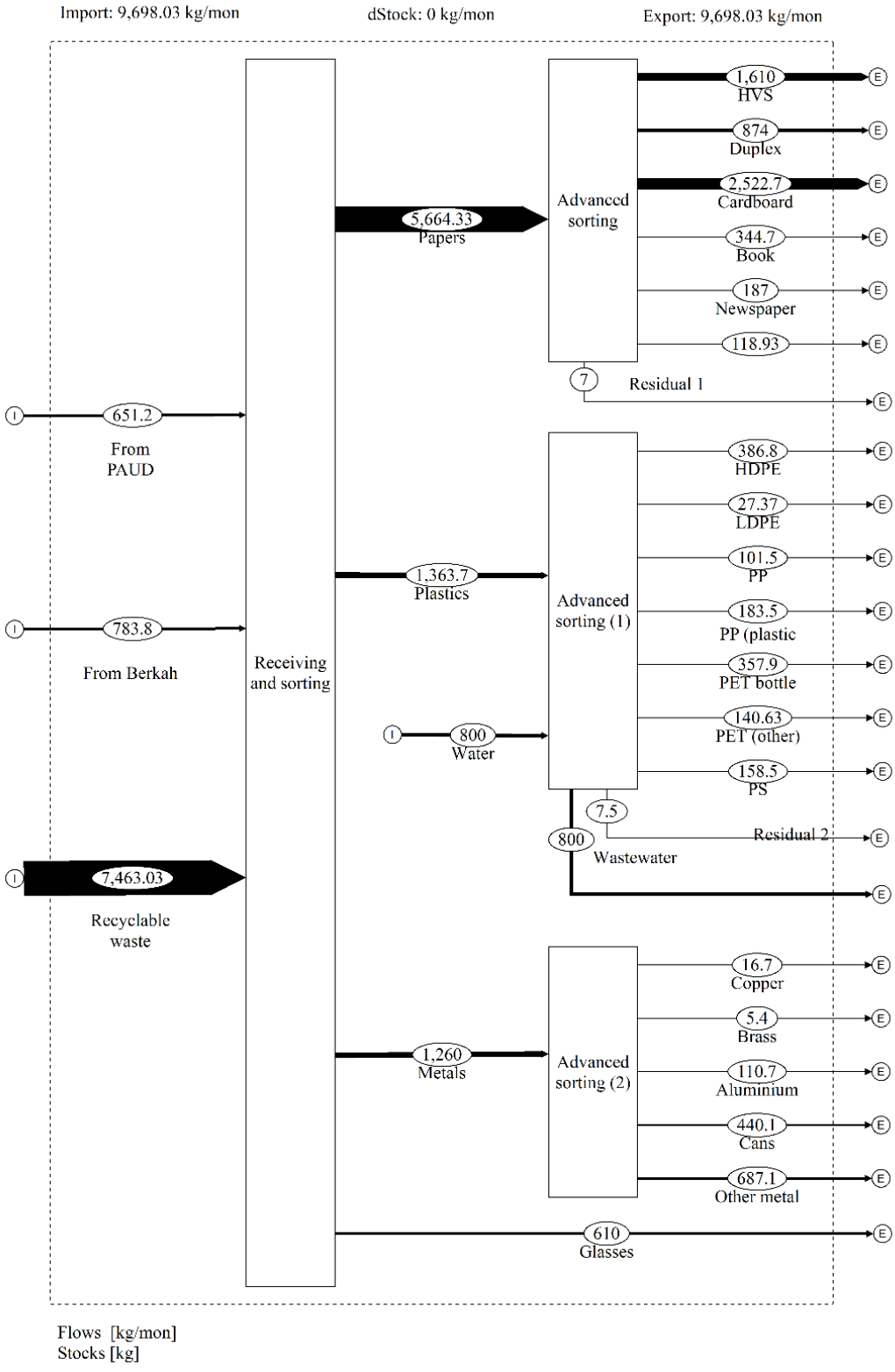

Figure 7 Material flow analysis of Sicanang waste bank

p-ISSN 2579-9150; e-ISSN 2579-9207, Volume 3, Number 1, page 28 - 46, October 2019
Accredited SINTA 2 by Ministry of Research, Technology, and Higher Education of The Republic of Indonesia No. 23/E/KPT/2019 on August 8th, 2019 from October 1st, 2018 to September 30th, 2023

Figure 8 presents the Sankey diagram of waste bank activities. In total, there are 10,187.52 kg recyclable wastes into the system. On the left of the diagram shows the input of recyclable wastes. Several single flow arrows present the type of waste and material as a result of sorting activity. The single waste flows end in recyclable items as the result of waste bank activities. The sum flow arrows indicate the amount of the collected and sorted recyclable wastes at the waste bank.

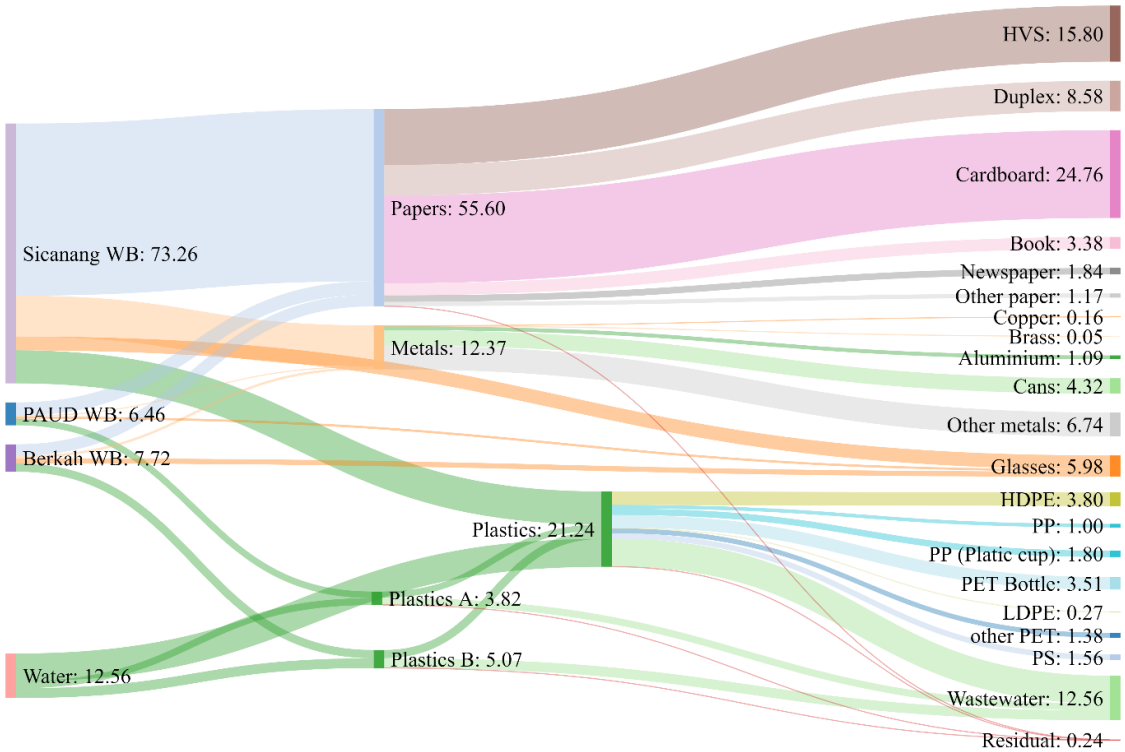

Figure 8 Sankey diagram of waste bank activities per month (percentage)

In total around 57% of the collected recyclable waste is paper, 8.68% of the total is plastic, 12% is metal, and 6% the remaining recyclable waste is glass. This percentage shows that waste banks process more paper waste compared to other types of waste, such as paper, metal, and glass. This result is similar to a study conducted in Yogyakarta, consist of 51% of paper and 46% of plastic (Putra *et al.,* 2018). A study of the composition of household waste in the city of Medan, as shown in Table 2, found that plastic waste was the second position after organic or the highest in the category of inorganic waste, which was 17.6%. However, this situation is slightly different compared to the percentage of plastic managed by waste banks.

p-ISSN 2579-9150; e-ISSN 2579-9207, Volume 3, Number 1, page 28 - 46, October 2019
Accredited SINTA 2 by Ministry of Research, Technology, and Higher Education of The Republic of Indonesia No. 23/E/KPT/2019 on August 8th, 2019 from October 1st, 2018 to September 30th, 2023

The presence of the scavengers is predicted to reduce the amount of plastic waste reaching the waste banks. Physically, plastic waste is relatively easy to find in the surrounding environment and is resistant to weather condition. It is different conditions with paper waste, where paper wastes are not weather resistant. Waste producers will store their paper wastes indoor to keep it dry and not exposed to rain. This condition causes the scavengers relatively challenging to find it.

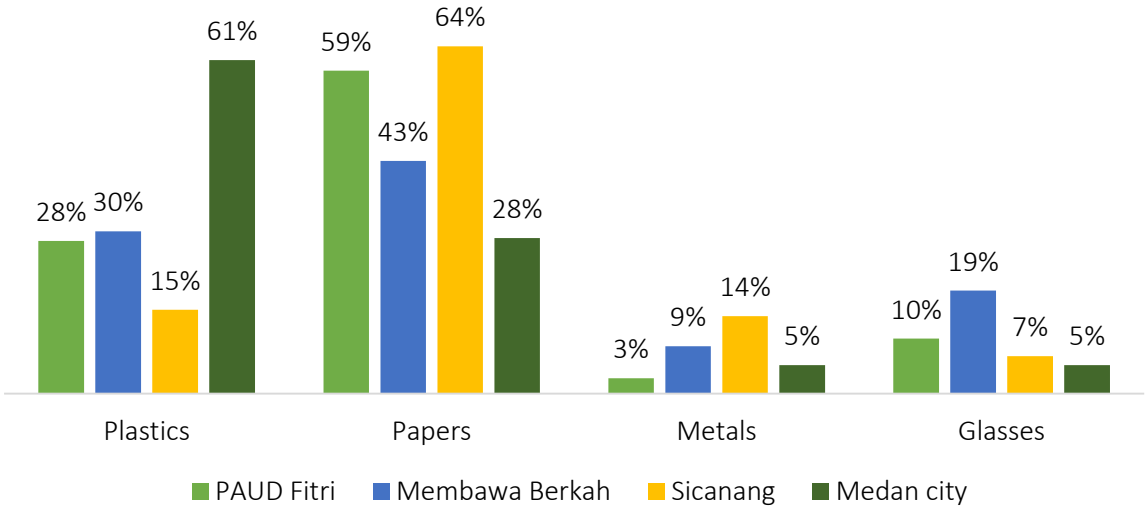

Figure 9 Composition of output material

Waste banks are one part of the informal sector in waste management in Indonesia. In addition to waste banks, some scavengers target recyclable waste. It is estimated that there are around 3000 scavengers in the city of Medan (Sibuea, 2019). They cover many areas: transfer waste station, roadsides, residential areas, commercial areas, and areas that have the potential to find recyclable waste. They sell the waste not to waste banks, but to junkman or lapak. In Indonesia, there are stakeholders (formal and informal) who play an essential role in collecting recycled wastes scavengers: waste collector crews, junkmen (waste traders), intermediates (lapak), dealers (bandar) and brokers (Damanhuri and Padmi, 2012). The authors estimate that there is still much plastic waste that has not been manage. According to Jambeck *et al.* (2015), Indonesia is the top three countries that mismanaged plastic waste in the World (Jambeck *et al.,* 2015).

p-ISSN 2579-9150; e-ISSN 2579-9207, Volume 3, Number 1, page 28 - 46, October 2019
Accredited SINTA 2 by Ministry of Research, Technology, and Higher Education of The Republic of Indonesia No. 23/E/KPT/2019 on August 8th, 2019 from October 1st, 2018 to September 30th, 2023

Table 2 HW composition of Medan City

Composition	%
Organics	61.4
Plastic	17.6
Paper	8.2
LWTR	1.5
Glass	1.5
Metal	1.5
Inert	0.2
Misc.	8.3

Source: (Khair *et al.,* 2019)

Figure 10 presents the percentage of input and output material for waste bank activities. Recyclable wastes account for 87.4% of the total amount of the input material, and 12.6% is water. The waste bank activities generate 87.2% recyclable items, 12.6% wastewater, and 0.2% residues. The use of water for cleaning activities is still high; this indicates that the quality of recyclable wastes is still many polluters. The polluters need to be discarded. In this case, waste banks need to educate their members to improve the quality of the recyclable waste.

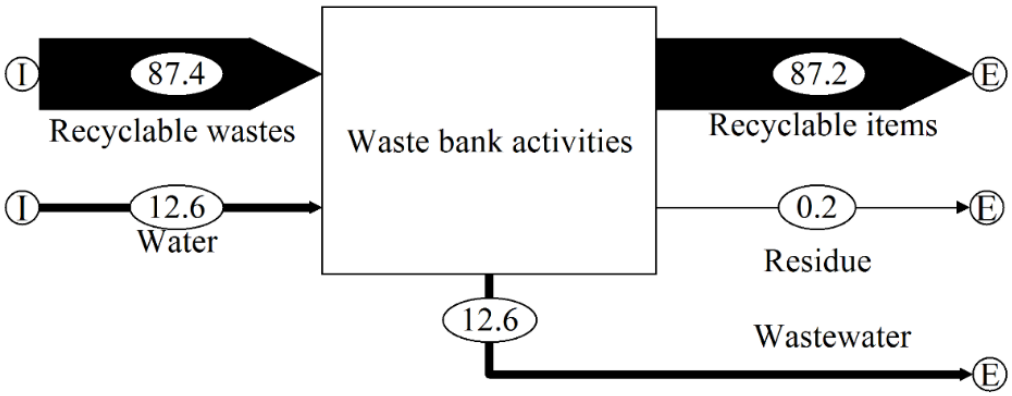

Figure 10 Percentage of input and output material for waste bank activities

This study proposes that improvement in the method handles waste at home, and the appropriate policies for waste banks accompany it. The community should be able to change the habit of handling waste, starting from its source. As much as possible the community should separate recyclable wastes from polluters starting from the home, by separating wet garbage or rotting garbage. The management may consider issuing guidelines such as always remove cap

p-ISSN 2579-9150; e-ISSN 2579-9207, Volume 3, Number 1, page 28 - 46, October 2019
Accredited SINTA 2 by Ministry of Research, Technology, and Higher Education of The Republic of Indonesia No. 23/E/KPT/2019 on August 8th, 2019 from October 1st, 2018 to September 30th, 2023

(cover), rinse with water, clean it, and put it in a container such as a basket (Tachikawa City, 2013) (Ota City, 2017) or not accept unclean items that have sludge or grease (Nakano City, 2019).

4. CONCLUSION

As one part of waste management, waste banks must continue to innovate and make improvements. In addition to the community, the government plays a significant role in supporting the future of waste banks. The government plays a role in providing management support training, regulation, guidelines, systems or funding as mandated in Indonesia's Law 18/2008 on Waste Management. This study found that the activities of waste banks are still traditional, which is a lack of technology adoption. In the future, the waste bank should be more efficient and able to manage large amounts of wastes if they incorporate innovative tools because of the vast potential for recyclable wastes. The findings of this study are essential to the development of useful instruments and policies for improving the waste bank activity in support of waste management. The MFA of waste bank activities give an understanding of the use of resources. In the future, it is necessary to conduct further research that covers recyclable waste from "*cradle to grave*" in a city or regional scale.

REFERENCES

Alias, F. S., Abdul Manaf, L., Ariffin, M., and Abdullah, S. H., 2019. Enhancing the Potential of Recyclables Waste Collection through Waste Bank Programme: Experience from Hei in Malaysia. *Planning Malaysia Journal.*

Brunner, P. H., and Rechberger, H., Practical Handbook of Material Flow Analysis, CRC Press, 2016

Challcharoenwattana, A., and Pharino, C., 2015. Co-Benefits of Household Waste Recycling for Local Community's Sustainable Waste Management in Thailand. *Sustainability.* 7(6):7417–7437.

Condeixa, K., Haddad, A., and Boer, D., 2017. Material flow analysis of the residential building stock at the city of Rio de Janeiro. *Journal of Cleaner Production.*

Damanhuri, E., and Padmi, T., 2012. The Role of Informal Collectors of Recyclable Waste and Used Goods in Indonesia. In Damanhuri, E. (Ed.), Post-Consumer Waste Recycling and Optimal Production. IntechOpen, Rijeka.

Dhokhikah, Y., Trihadiningrum, Y., and Sunaryo, S., 2015. Community participation in household solid waste reduction in Surabaya, Indonesia. *Resources, Conservation and Recycling.* 102:153-162.

p-ISSN 2579-9150; e-ISSN 2579-9207, Volume 3, Number 1, page 28 - 46, October 2019
Accredited SINTA 2 by Ministry of Research, Technology, and Higher Education of The Republic of Indonesia No. 23/E/KPT/2019 on August 8th, 2019 from October 1st, 2018 to September 30th, 2023

Dinas Lingkungan Hidup Kota Medan, 2017. Data Bank Sampah Kota Medan. Medan.

Faraca, G., and Astrup, T., 2019. Plastic waste from recycling centres: Characterization and evaluation of plastic recyclability. Waste Management.

Islam, M. T., and Huda, N., 2019. Material flow analysis (MFA) as a strategic tool in E-waste management: Applications, trends and future directions. *Journal of Environmental Management.*

Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., Narayan, R., and Law, K. L., 2015. Plastic waste inputs from land into the ocean. *Science.* 347(6223):768 LP – 771.

Ju, M., Osako, M., and Harashina, S., 2017. Food loss rate in food supply chain using material flow analysis. *Waste Management.*

Khair, H., Rachman, I., and Matsumoto, T., 2019. Analyzing household waste generation and its composition to expand the solid waste bank program in Indonesia: a case study of Medan City. *Journal of Material Cycles and Waste Management.*

KLH, 2013. Buku: Profil Bank Sampah Indonesia 2013 : Kementerian Lingkungan Hidup. http://www.menlh.go.id/profil-bank-sampah-indonesia-2013/. [10 May 2019].

KLHK, 2018. Indonesia Sampaikan Metode Pengelolaan Sampah Berbasis Masyarakat ke Dunia Internasional. http://ppid.menlhk.go.id/siaran_pers/browse/1166. [17 May 2019].

Maryati, S., Arifiani, N. F., Humaira, A. N. S., and Putri, H. T., 2018. Factors influencing household participation in solid waste management (Case study: Waste Bank Malang). In IOP Conference Series: Earth and Environmental Science.

Naipospos, H., 2017. Coba Tebak Berapa Jumlah Sampah di Kota Medan per Hari? Anda Pasti Akan Tercengang - Tribun Medan. http://medan.tribunnews.com/2017/09/29/coba-tebak-berapa-jumlah-sampah-di-kota-medan-per-hari-anda-pasti-akan-tercengang. [15 December 2018].

Nakano City, 2019. How to Separate Recyclable Materials and Dispose of Them Special Edition. Nakano City.

Ota City, 2017. How to dispose and separate your waste and recyclable waste. Ota City.

Priyo, A., Sulami, N., Murayama, T., and Nishikizawa, S., 2018. Current Issues and Situation of Producer Responsibility in Waste Management in Indonesia. *Environment and Natural Resorces Journal.*

Purnama Putra, H., Damanhuri, E., and Sembiring, E., 2018. Integration of formal and informal sector (waste bank) in waste management system in Yogyakarta, Indonesia. *MATEC Web of Conferences.*

p-ISSN 2579-9150; e-ISSN 2579-9207, Volume 3, Number 1, page 28 - 46, October 2019
Accredited SINTA 2 by Ministry of Research, Technology, and Higher Education of The Republic of Indonesia No. 23/E/KPT/2019 on August 8th, 2019 from October 1st, 2018 to September 30th, 2023

Putri, A. R., Fujimori, T., and Takaoka, M., 2018. Plastic waste management in Jakarta, Indonesia: evaluation of material flow and recycling scheme. *Journal of Material Cycles and Waste Management.*

Putri, N., 2018. KLHK Sebut Bank Sampah Beri Pendapatan Rata-rata 1 M per Tahun. https://news.detik.com/berita/d-4328876/klhk-sebut-bank-sampah-beri-pendapatan-rata-rata-1-m-per-tahun. [22 May 2019].

Raharjo, S., Junaidi, N. E., Bachtiar, V. S., Ruslinda, Y., Rachman, I., and Matsumoto, T., 2017. Development of community-based waste recycling (garbage bank and 3R waste treatment facility) for mitigating greenhouse gas emissions in Padang City, Indonesia. In 2016. *Management and Innovation Technology International Conference*, MITiCON 2016.

Salim, R., 2013. Waste Not, Want Not : "Waste Banks" in Indonesia. World Bank Blogs https://blogs.worldbank.org/eastasiapacific/waste-not-want-not-waste-banks-indonesia. [27 September 2019].

Satori, M., Megantara, E. N., Primiana, F. M. S. I., and Gunawan, B., 2018. Review of the influencing factors of integrated waste management. *International Journal of GEOMATE*.

Sibuea, P., 2019. Medan Kota Terkotor di Indonesia, 3.000 Pemulung Siap Membersihkan - Medan Metro -MedanBisnisDaily.com. http://www.medanbisnisdaily.com/news/online/read/2019/01/25/64500/medan_kota_terkotor_di_indonesia_3_000_pemulung_siap_membersihkan/. [1 June 2019].

Statistic of Medan Municipality, 2017. Kota Medan dalam Angka 2017 (Medan Municipality in Figures 2017). Medan.

Susanto, I., and Adi, L., 2018. Pengurangan Baru Mencapai 2.12 Persen. http://perpustakaan.menlhk.go.id/pustaka/home/index.php?page=detail_news&newsid=321. [22 May 2019].

Tachikawa City, 2013. Sorting and Disposing Handbook of Recyclable Resources and Garbage. Tachikawa.

Temesi Recycling, 2019. Waste Banks Temesi Recycling. Temesirecycling.com http://temesirecycling.com/waste-banks/. [27 September 2019].

Van Ewijk, S., Stegemann, J. A., and Ekins, P., 2018. Global life cycle paper flows, recycling metrics, and material efficiency. *Journal of Industrial Ecology.*

Wijayanti, D. R., and Suryani, S., 2015. Waste Bank as Community-based Environmental Governance: A Lesson Learned from Surabaya. *Procedia - Social and Behavioral Sciences.*

Widyarsana, I.M.W and Salmaa, K. 2019. Evaluation of Waste Management Achievement in Padangtegal Pekraman Village, Ubud Sub District, Gianyar District, Bali. *Indonesian Journal of Urban and Environmental Technology*. 2(2):102-119, April 2019. DOI:http://dx.doi.org/10.25105/urbanenvirotech.v0i0.4365

p-ISSN 2579-9150; e-ISSN 2579-9207, Volume 3, Number 1, page 28 - 46, October 2019
Accredited SINTA 2 by Ministry of Research, Technology, and Higher Education of The Republic of Indonesia No. 23/E/KPT/2019 on August 8th, 2019 from October 1st, 2018 to September 30th, 2023

Wulandari, D., Hadi Utomo, S., and Narmaditya, B. S., 2017. Waste bank: waste management model in improving local economy. *International Journal of Energy Economics and Policy.*