Solid waste management in a coastal area (Study Case: Sukolilo Sub-district, Surabaya)

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Abstract. The waste bank is one of the formal sectors to reduce waste in the city of Surabaya. Sukolilo Sub-District has 22 active waste banks, but eight waste banks are inactive. Also, the TPS is carrying out plastic waste sorting. The sorting activity at the TPS is much greater than the reduction through the waste bank. The purpose of this research is to analyze the recovery factor (RF) through the waste bank and TPS. The method used is interviews with waste banks and TPS as the formal sector and collectors as the informal sector. The results show that the recovery factor (RF) in Sukolilo District is still far from standard. Plastic RF in Sukolilo District is 4.79% from the standard which can be reduced by 50%. This waste reduction involves the roles of the formal and informal sectors.

Keywords: Plastic, Sukolilo, TPS, Waste bank.

1. Introduction
Waste management is one of the crucial problems to handle [1], especially in Surabaya as the second-largest city in Indonesia. The population overgrows in Surabaya due to easy access, economic development, and the City of Surabaya is the gateway to Kertosusila. A high population is in line with a high amount of waste generation. This condition must be balanced with waste management, such as reduce, reuse, and recycle to reduce handling at the end (TPA). Good waste management will also reduce waste being carried into the sea. As much as 80% of waste in the sea comes from waste on land that does not have adequate waste management [2]. The river is the main transportation that carries waste from land to sea [3]. Most of the waste brought into the sea is plastic, which comes from daily domestic activities and industrial activities [4].

Sukolilo Sub-District is located in a coastal area and traversed by the Jagir river, which separates Sukolilo and Rungkut Sub-Districts. This river carries plastic waste downstream onto the Wonorejo coast. Sukolilo District, which is located around the river, contributes to the contribution of garbage entering the Wonorejo coast. Garbage at sea lasts a long time and can form microplastics. Wonorejo
Coast, as the downstream of Jagir river, contains a lot of macro and microplastics. Microplastics found in this area were 57% polyester, 24.5% low-density polyethylene (LDPE), and 18.7% polypropylene (PP) [5]. The amount of plastic waste on the Wonorejo coast and its surroundings is 417.485 tons/year, with a catchment area of 32.4 km² [6]. One of the waste management that has been implemented in Sukolilo District is establishing a waste bank. The waste bank is an inorganic MSW management system on a communal basis that encourages the community to take part in separating the waste and recycling the waste to boost its economic value [7]. Waste banks usually apply a savings system hence the money they get is saved and given out once a year. However, some people sell directly to small scrap dealers (lapak) because the price is higher than the waste bank.

The purpose of this study is to analyze the amount of waste reduction that has been carried out in Sukolilo Sub-district therefore it can be analyzed that waste reduction reduces waste carried into the sea. The hope is to provide input to the government and related stakeholders in good waste management to reduce waste entering the sea.

2. Material and Methods

Research Study Area

Sukolilo Sub-district is one of the coastal areas in the city of Surabaya. The total population in East Surabaya is 114,309 [8]. This sub-district is composed of housing, residential and educational areas. Sukolilo Sub-district is the second most populated area in East Surabaya. The formal and informal sector plays a vital role in waste management in Sukolilo District. The formal sector is the waste bank and transfer station, while the informal sector is the small scrap dealers (lapak) and largescale enterprises (bandar) who are mostly found in the former Keputih TPA.

Data Collection Methodology

Transfer Station Samples

The number of transfer stations in Sukolilo Subdistrict was 8, which in this study chosen two transfer stations with different categories. This transfer station is used to determine the composition of household waste from Sukolilo Sub-District. Medokan Semapir transfer station and Arif Rahman Hakim transfer station were taken as samples. Medokan Semampir transfer station was taken because it has the most waste banks, while Arif Rahman Hakim transfer station has the fewest waste banks.

Waste Bank Samples

The number of waste bank samples was determined using simple random sampling. Eight waste banks were analyzed out of the 22 waste banks in East Surabaya. Interviews were conducted with the management of the waste banks to find out the amount of generation, frequency of weighing, number of customers, turnover, operational costs, and buyers of waste from the waste banks. Surabaya has one central waste bank, which is also located in the East of Surabaya. The sample was taken in this central waste bank that collects recycling material from other waste banks around Surabaya City.

3. Result

Household Waste Generation and Composition Rate

The rate of waste generation in Sukolilo District is influenced by the number of residents and the different lifestyles of each house. Reduction activities through waste banks, small scrap dealers (lapak), large-scale enterprises (bandar), composting, and recycling can reduce the waste generation of each house. The rate of waste generation in Sukolilo District is 0.38 kg/person per day [9]. The composition of household waste is obtained from direct surveys at Medokan Semampir transfer station and Arif Rahman Hakim transfer station. These two transfer stations represent the village (kelurahan), which has many waste banks and does not have a waste bank. The enormous amount of waste is still dominated by compostable waste (36%), followed by paper (12%) and plastic (11%) (figure 1).
Figure 1. Composition of Average Household Waste in Sukolilo Sub-District.

The amount of plastic waste ranks third following compostable waste and paper. The most massive composition of plastic waste is LDPE (29%). Figure 2 shows that LDPE type plastic is the most widely used in households.

LDPE plastic is commonly used in various colors and sizes. According to Cabanes et al. (2020), in all market sectors globally, more than 8 million tonnes of LDPE are required for the packaging of goods. Besides, LDPE is used in flexible packaging, especially as shopping bags. The consumption of shopping bags in Europe reaches 100 billion bags per year, of which only 7% is recycled. This shows that LDPE plastic is used worldwide and ends up becoming waste due to minimal management.

Waste Bank

Sukolilo District has 23 active waste banks with a total of 296 customers. All waste banks in Sukolilo Sub-District sell their waste to the Surabaya City Central Waste Bank. Central Waste Bank is the only waste bank in Surabaya that receives waste not only from unit waste banks but from individuals, schools, and companies. Central Waste Bank is located outside Sukolilo Sub-District namely in Gubeng Sub-District, East Surabaya. Customer activeness is the main factor that determines the amount of generation in the waste bank. Customer activity is greatly influenced by the system run by the waste bank. As many as eight waste banks in Sukolilo Sub-District carry out various weighing schedules from once a month to once in 3 months. The waste bank working system also influences the weighing frequency.
Waste banks that implement a savings and loan system have many customers and an increasing weighing frequency. The frequency of this weighing also affects the rate of the waste generation entering the waste bank. The following are the results of weighing total waste and total plastic in a waste bank (figure 3–4). The results show that about 30% of the total waste generation in the waste bank is in both sheet and non-sheet plastic. The emergence of the Tunas Muda Waste Bank is the smallest compared to the others. This is because there is no savings and loan system so that the number of customers is fewer and not very active. The inactivity of the waste bank can be proven by a weighing schedule every 2-3 months. Meanwhile, other waste banks apply a savings and loan system and a frequency of weighing once a month. Figure 3 shows that the seven waste banks generate a higher generation than the Tunas Muda Waste Bank.

**Figure 3.** Waste Generation Rate in Waste Bank.

**Figure 4.** Plastic Waste Generation Rate in Waste Bank.

The total population of Sukolilo Sub-District is 114,309 people with a generation per person of 0.38 kg/day. A total of 8 waste banks conducted by the research could reduce waste by 18,849.27
kg/year. Average per month of 201 kg/month with 11x weighing. The waste bank serves 296 households or the equivalent of 1,184 people. Waste bank activities can reduce waste by 3.74 kg/person/month. Sukolilo Sub-District has 22 active waste banks, so the reduction result per person per month will be multiplied by the total customers to determine the total reduction in the waste bank (Table 1).

Table 1. Waste Reduction through a waste Bank in Sukolilo Sub-District.

| Parameter                                      | Amount | Units   |
|------------------------------------------------|--------|---------|
| Total waste bank                               | 22     | Units   |
| Total customers of waste bank                  | 296    | KK      |
| Number of members in 1 KK                      | 4      | people/KK |
| Total people served by a waste bank            | 1184   | people  |
| The average reduction                          | 3.74   | kg/person/month |
| Total reduction per year                       | 48,665.73 | kg/year |
| The average reduction of each waste bank       | 201.1  | kg/month |

A waste bank in Sukolilo Sub-District can reduce plastic waste up to 201.1 kg/month or 60.3 kg/month. This waste bank activity is only able to reduce 0.34% of the total waste in Sukolilo Sub-District. Besides, it was only able to reduce 0.81% of the total dry waste generation or 0.016% of the total plastic waste produced. The reduction in transfer station in Sukolilo Sub-District was greater than that at a waste bank. Waste reduction through transfer station is 1.71% of all plastic generation in Sukolilo Sub-District.

Referring to the composition of waste and the recovery factor, the reduction potential in Sukolilo SubDistrict can ideally be increased. The recovery factor percentage has a much higher value than the existing reduction through the waste bank (Table 2). The plastic recovery factor value in Germany and Belgium reaches 100% due to using a closed system. In several other countries such as Japan (82%), France (70%), England (60%), and South Korea (51%). The existing recycling rate is 48% for Germany; 46.2% UK; 44.5% Belgium; 26.5% French; 16% Japanese; and 13.5% South Korea [10]. The value of recycling in these countries is very different from the conditions in Indonesia, precisely in Surabaya (Table 2).

Table 2. Percentage of Recovery Factors in Sukolilo Sub-District.

| Type of Solid Waste | % RF* | % RF at source (waste bank) | % RF at transfer station | Total % RF |
|---------------------|-------|----------------------------|--------------------------|------------|
| Plastic             | 50    | 0.3                        | 4.49                     | 4.79       |
| Paper               | 50    | 1.43                       | 3.3                      | 4.73       |
| Iron/metal          | 90    | 0.27                       | 0.74                     | 1.01       |

*Tchobanoglous et al., 1993

The existing recovery factor in Sukolilo Sub-District is still very far from the RF standard, which can be reduced from any type of waste. This condition is caused by low community participation in sorting the waste produced. Table 2 shows that RF is greater at the transfer station than at the source of waste. The RF value, which is still small, is a collective task to increase it so that it requires awareness from the community and adequate facilities for sorting it out. A concerning the implementation of infrastructure and facilities for waste management in handling household waste and household-like waste [11], the transfer station requirement does not have segregation. However, the existing conditions show that the most sorting is at transfer station compared to sources. In addition to
collecting waste from the source, the collector performs the sorting of waste that can be sold to increase income.

A waste reduction that can be reduced through the role of waste banks and transfer stations in Sukolilo Sub-district is 4.79% or 228.87 kg/day. The amount of reduction can reduce plastic waste entering the river and polluting the sea around Sukolilo Sub-district.

Plastic waste reduction can be improved by increasing the active role in the waste bank and transfer station in Sukolilo Sub-district.

The active role of the waste bank:
1. Implement a savings and loan system.
2. Collaborating with companies as CSR that support funds for waste banks so that they can be used to pay waste bank managers and take garbage to customers.
3. Enlarge the coverage of waste bank services.
4. Cooperate with plastic recycling companies to get high prices.

The Role of Transfer station:
1. Improve the transfer station facility to become 3R transfer station by finding a third party to support funds so that there will be a facility for sorting recyclable waste.

4. Conclusion
The waste bank activity in Surabaya can reduce the amount of plastic that is sent to the river and empties into the sea. Waste banks that are more active to open increase the activeness of the customer. The activity encourages customers to collect and deposit waste in the waste bank. Waste bank activities and sorting at transfer stations encourage people to reduce plastic waste dumped into the sea through rivers. The activities of the waste bank and transfer station in Sukolilo Sub-District reduce 4.65 tons/day of plastic waste. It is crucial to increase the reduction of waste through waste banks and transfer stations and link this system with the informal sectors. Several strategies can be developed to increase the number of waste recycled.

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