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The mapping of active waste banks based on Geographic Information System (GIS) as an effort for waste management in Surabaya City

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Abstract. This study aimed to determine the amount of distribution of active waste banks along with the composition and amount of waste generation in Surabaya City, as well as to provide a generation map for paper, plastic, and metal waste from Surabaya's active waste banks. The data of the research was obtained through the survey of all Surabaya City waste banks consisting of waste bank activity data, coordinate data, waste bank documentation, composition data, total waste generation, and East Java map. Based on the data obtained, the researchers mapped the waste banks using the ArcGIS 10.2 software. Based on the results of the research, there were 64 active waste banks in Surabaya City during May-July 2016 spread in five areas: 9 waste banks in Central Surabaya, 12 waste banks in West Surabaya, 12 waste banks in South Surabaya, 19 waste banks in East Surabaya, and 12 waste banks in North Surabaya. The waste composition and generation consist of paper waste of 8,254.3 kg/month, plastic waste of 2,870.5 kg/month, and metal waste of 2,352.3 kg/month. The distribution map of paper, plastic, and metal waste from GIS-based active waste banks can facilitate waste management in Surabaya City.

1. Introduction

Surabaya is one of the metropolitan cities that ranks second as the largest city in Indonesia. The recorded population in 2011 was 3,024,321 [1]. The high population will increase the quantity of waste generated [2]. The amount of waste that goes to Benowo Landfill, which has an area of 37,4 Ha, is 10.000 m³/day [3]. Benowo landfill will experience excess in capacity in accommodating waste if the amount of waste that is deposited remains high. The problem must be solved by managing waste, such as by utilizing the 3R system (*reduce, reuse, recycle*).

One of the efforts of waste management using 3R system is to perform waste reduction. However, garbage reduction in Surabaya City has only been implemented in several Integrated Waste Management Sites (TPST), such as the Sutorejo Depot TPST and some waste banks, so the waste management process is still not effective. Waste bank is one of the manifestations of 3R implementation strategy in waste management at its source at the community level. The implementation of waste bank in principle a form of social engineering to encourage people to sort their waste [4].

In this research, active waste banks were surveyed. Active waste banks were selected because they are assumed to have a significant contribution to the management of municipal solid waste. The survey of composition and waste generation in waste banks was performed by classifying waste into five types, namely paper waste, plastic sheets, plastic containers, metals, etc. that is in accordance with the condition that the waste is in accordance with the existing condition [5]. The selection of



waste was performed by looking at waste needs in the industry and the community. In addition, the selection of waste composition aimed to facilitate the display of mapping results to be more informative for stakeholders, such as the government.

This mapping used a system known as Geographic Information System (GIS). The basic capabilities of GIS are integrating various data operations, as well as analyzing, storing, and displaying them in the form of mapping based on geographical location [6]. The results of this research are the distribution of active waste banks in Surabaya City, the composition and the waste generation in the active waste banks of Surabaya City, and the distribution map of waste paper waste, plastic, and generation of the active waste banks in Surabaya City.

2. Research Methods

Primary and secondary data were collected at waste banks in Surabaya City. The implementation of mapping and analysis activities were conducted at the Environmental Laboratory of the Department of Biology, Faculty of Science and Technology, Universitas Airlangga, Surabaya. The research activities lasted from May to July 2016. The material used for all research activities was the map of the East Java Province. The tools used in this research were Garmin etrex GPS 30, Asus Zenfone 4S with 8-Megapixel Camera (3264x2448), a number of software supporting the activity of mapping waste banks, namely ArcGIS 10.2, Global Mapper v.14.00, Google Earth, and Microsoft Excel.

Data collection consists of primary and secondary data collection. Primary data consists of the data of the waste bank's activities, the data of waste bank coordinates, and waste bank documentation. Secondary data consists of composition and waste generation, as well as basic map. The collected data was processed and mapped using the *software* ArcGIS 10.2, Global Mapper v.14.00, Google Earth, and Microsoft Excel.

3. Result and Discussion

3.1. *Distribution of active waste banks in Surabaya City*

An active waste bank is a waste bank that for the last three months at the time of the research (May-July 2016) was still in operation. There were 64 active waste banks in Surabaya City. Waste banks were spread in five areas, namely Central Surabaya with 9 waste banks, West Surabaya with 12 waste banks, South Surabaya with 12 waste banks, East Surabaya with 19 waste banks, and North Surabaya region with 12 waste banks.

The most active area was East Surabaya with 19 waste banks. The high number of waste banks in East Surabaya is supposedly because the area has the highest population in Surabaya City. In 2013, the total population of the area was recorded at 738,123 residents. It is directly proportional to Surabaya Pusat with the lowest population at 360,258 that had the least number of waste banks in Surabaya with 9 garbage banks [7]. Usually, the higher the population, the higher the number active waste banks, and vice versa. This is due to high waste generation, so the need for waste banks is also high in the area [8].

These active waste banks are supported by several factors. Firstly, the community is enthusiastic and supports the waste banks' activities because the waste bank system benefits the community economically, environmentally, and socially [8]. Secondly, the support of the Surabaya City Government in maintaining and developing the waste bank in order to always be active is essential by conducting the competitions in which all kampongs in Surabaya participate. Merdeka dari Sampah (MDS) and Surabaya Green and Clean (SGC) are examples of competitions held by the Surabaya City Government to maintain and develop waste banks so that they are always active. Community empowerment efforts are heavily controlled by environment-based activities. It supports the sustainability of waste banks as a form of waste management effort in Surabaya City.

3.2. *Composition and rate of waste generation from active waste banks in Surabaya*

Active waste banks in Surabaya City sort the waste they receive from their customers. The waste sorting is aimed to separate five groups of waste, namely papers, plastic sheets, plastic containers, metals, and others. The types of waste in this sorting process can be seen in Table 1. Those types of waste were selected because there were high quantities of those materials in every waste bank. The waste generation and composition in waste banks in Surabaya City can be seen in Table 1.

Table 1. Waste composition and generation in Surabaya City's Waste Banks Years 2015-2016

No.	Waste Components	Waste Generation (kg)					Total
		Central Surabaya	West Surabaya	South Surabaya	East Surabaya	North Surabaya	
1.	Cardboard	443.1	752.1	410.1	849.3	347.8	2,802.4
2.	Duplex cardboard	394.6	626.3	383.7	806.3	292.2	2,503.1
3.	Newspaper	156.0	247.4	169.3	287.2	165.4	1,025.3
4.	Plastic Sheets	31.1	147.3	13.2	91.1	13.2	295.9
5.	Plastic bags	20.0	19.9	31.5	54.3	12.1	137.8
6.	Plastic cups	116.7	83.7	100.0	112.6	69.5	482.5
7.	Plastic bottles	201.8	209.9	225.4	394.7	150.0	1,181.8
8.	Park	136.5	106.7	144.6	340.4	80.3	808.5
9.	Aluminium	52.2	45.3	31.9	50.1	21.4	200.9
10.	Iron	34.5	83.1	53.8	223.9	33.3	428.6
11.	Others	173.5	638.0	214.4	753.9	143.8	1,923.6
Total		1,760.0	2,959.7	1,777.9	3,963.8	1,329.0	11,790.4

Based on Table 1, waste banks succeeded in reducing the waste dumped into to the landfill by 11,790.4. The high amount of reduction is due to several supporting factors. First, customers are enthusiastic in sorting through garbage collection, with the Leaders of Rukun Warga consistently motivating customers to perform waste management with waste banks. Second, customers of waste banks in Surabaya City are mostly middle to lower economic-class residents. According to [8], in Surabaya, waste banks are managed by local communities as small-scale business activities with community participation and a socio-economic orientation. Waste banks are developed more significantly in the kampongs than in the housing areas. Kampong residents have more enthusiasm than the residents of housing areas. They are interested in the concept of waste banks because of the profits from the sale of waste that can support their daily living expenses. In contrast, housing communities are filled with middle to high income residents, who are not interested in waste banks because their economic conditions are steadier. Thirdly, customers know the many benefits of waste bank management, ranging from the environmental, economic, to social benefits.

3.3. Mapping of the Distribution Paper, Plastic, and Metal Waste from Active Waste Banks in Surabaya City Based on Geographic Information System (GIS)

The mapping of paper, plastic, and metal waste distribution from active waste banks in Surabaya City based on Geographic Information System (GIS) was performed using the Geographical Information Systems (GIS) software. The data on waste composition and generation obtained needed to be processed in order to obtain information and ensure readability by stakeholders. GIS has an excellent ability to modify the shape, colour, and size of symbols of each data so as to facilitate the presentation of information [9].

The waste composition and generation consist of paper waste of 8,254.3 kg/month, plastic waste of 2,870.5 kg/month, and metal waste of 2,352.3 kg/month. The mapping of paper, plastic, and metal waste distribution from active waste banks in Surabaya City can be seen in Figure 1. The distribution map of paper, plastic, and metal waste from GIS-based active waste banks can facilitate waste management in Surabaya City.

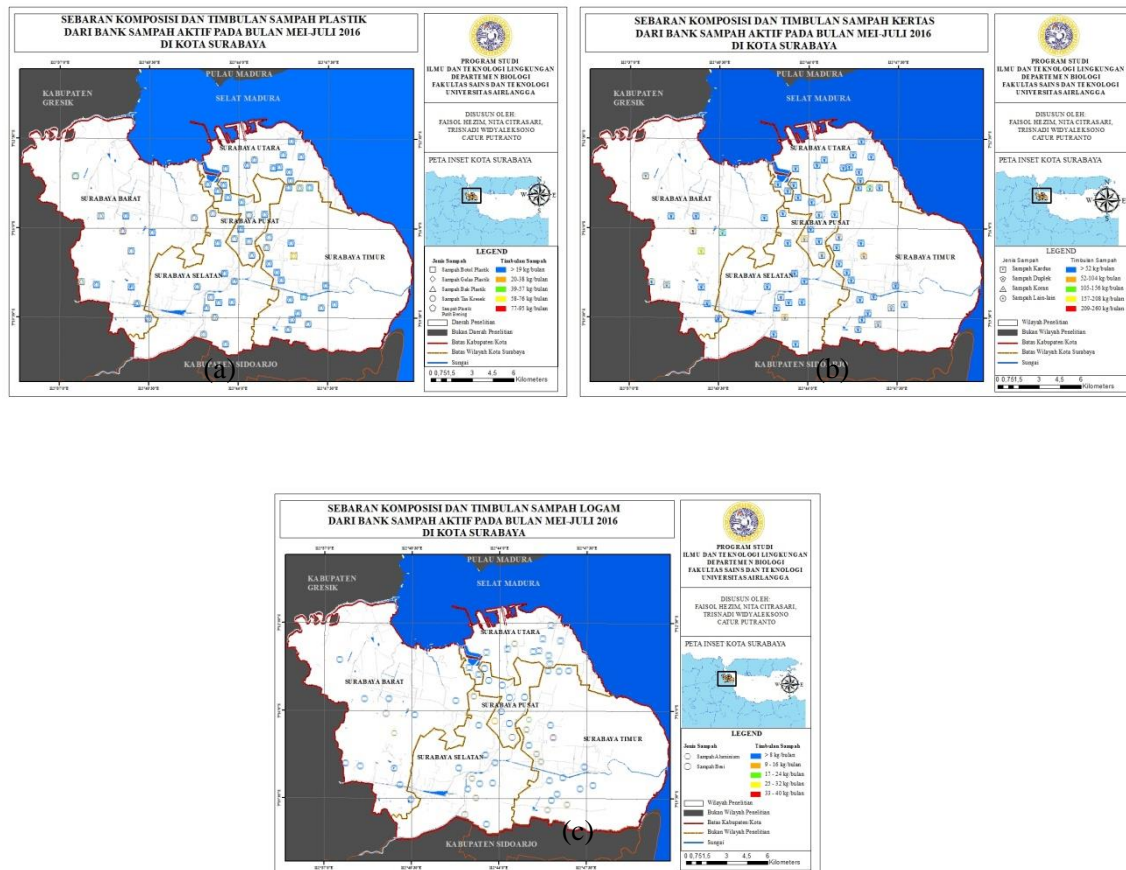


Figure 1. Distribution map of waste generation from active waste banks in Surabaya, a: paper waste, b: plastic waste, c: metal waste.

4. Conclusion

Active waste bank in Surabaya City amounted 64 waste bank spread in five areas: 9 waste banks in Central Surabaya, 12 waste banks in West Surabaya, 12 waste banks in South Surabaya, 19 waste banks in East Surabaya, and 12 waste banks in North Surabaya. The waste composition and generation consist of paper waste of 8,254.3 kg/month, plastic waste of 2,870.5 kg/month, and metal waste of 2,352.3 kg/month. The distribution map of paper, plastic, and metal waste from GIS-based active waste banks can facilitate waste management in Surabaya City.

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