# Non Residential Solid Waste Reduction in Krembangan District, North Surabaya

*Talent Nia Pramestyawati[1] dan I.D.A.A. Warmadewanthi[2]*

[1] *Environmental Departement, Institut Teknologi Adhi Tama Surabaya*
[2] *Environmental Departement, Institut Teknologi Sepuluh Nopember*

## ARTICLE INFORMATION

## ABSTRACT

*Reduction of non-residential solid waste is important because it can reduce the generation of solid waste in Benowo Landfill. Krembangan District is one of the districts in North Surabaya that was chosen as a research area however, there is no data about the existing and reduction potential of non-residential solid waste in Krembangan District. The purposes of this research are the identification of existing and reduction potential of non-residential solid waste in Krembangan District. There are 21 samples for this research. Public facility samples contain education facilities, offices, worship places, commercial places, medical centres and street sweeping. Total generation of solid waste from public facilities is 10.179,74 kg/day. Existing reduction of solid waste in source and transfer station are 158,1 kg/day and 472,53 kg/day. The reduction potential of non-residential solid waste is based on the optimal recovery factor. Reduction potential with composting and recycle activities are 3.668,31 kg/day and 694,67 kg/day.*

***Keyword:*** *Potential reduction; Krembangan district; Non residential solid waste*

## EMAIL

talentnia@itats.ac.id

## PUBLISHER

## ABSTRAK

Reduksi sampah sejenis sampah rumah tangga penting karena dapat mengurangi timbulan sampah di TPA Benowo. Kecamatan Krembangan merupakan salah satu kecamatan di Surabaya Utara yang terpilih menjadi lokasi penelitian karena belum ada data reduksi eksisting dan potensi reduksi dari sampah sejenis sampah rumah tangga di Kecamatan Krembangan. Tujuan penelitian ini adalah mengidentifikasi reduksi eksisting dan potensial reduksi dari sampah sejenis sampah rumah tangga di Kecamatan Krembangan. Terdapat 21 sampel fasilitas umum yang terdiri dari fasilitas pendidikan, perkantoran, tempat ibadah, fasilitas komersial, fasilitas kesehatan dan sapuan jalan. Timbulan sampah dari fasilitas umum sebesar 10.179,74 kg/hari. Reduksi eksisting sampah di sumber sampah dan TPS sebesar 158,1 kg/hari dan 472,53 kg/hari. Potensi reduksi sampah sejenis sampah rumah tangga didasarkan pada faktor recovery optimal sampah. Potensu reduksi dengan kegiatan pengomposan dan daur ulang sebesar 3.668,31 kg/hari dan 694,67 kg/hari.

***Kata kunci:*** *Potensi reduksi; Kecamatan Krembangan, Sampah Sejenis Sampah Rumah Tangga*

## INTRODUCTION

In 2011, solid waste generation in Surabaya about 1.075 tons/day, it had increased about 1.400 tons/day in 2014. The generation had increased about 30% 4 years [1]. Non-residential solid waste is solid waste that produced from public facilities such as education, commercial and other facilities [2]. Solid waste produced from public facilities contribute to increasing solid waste

generation in Benowo Landfill, so data about non-residential solid waste is important for integrated solid waste management in Surabaya City.

Data about non-residential solid waste from North Surabaya is not available, so this research took placed at one of the districts in North Surabaya. Krembangan District is one of the districts in North Surabaya that include into Development Area V. Development Area V concern to develop industrial, commercial, and service area [3], so Krembangan District has the increasing potency of solid waste generation. Krembangan district is the only one district in North Surabaya that has 3R Transfer Station.

The national target of solid waste reduction is 30% at the end of 2025 [4]. Existing reduction and reduction potential of non-residential Solid Waste in North Surabaya District are not available, so research about the existing reduction of non-residential solid waste must be important. Reduction potential is calculated based on the recovery factor of non-residential solid waste. Data about reduction potential can be used to arrange strategies of solid waste reduction so it can reach the national target of solid waste reduction

## METHOD

### Analysis of sampling location

Krembangan District has 5 sub-districts. Based on the density of population, there are 3 sub-districts be the sample location. Sub-districts that have the highest, average, and lowest density of population are Dupak Sub-district, Kemayoran Sub-district, and Perak Barat Sub-district. Sample of public facilities consist of education facilities such as elementary school, junior high school, and senior high school; offices; health centers such as hospital and health clinic; commercial facilities such as hotels, minimarket, traditional markets, and restaurants; street sweeping and worship houses. Public facility samples are calculated from the total amount of public facilities [5]. There are 21 public facilities samples. Equation about total sample calculated in equation (1). Table 1 shows the result of the sample calculation.

$$S = Cd \times \sqrt{Ts} \tag{1}$$

Explanation:
S     = Total sample;
Ts    = Total population of public facilities
Cd    = Coefficient for non residential (1)

Table 1. Total Sampling Location

| Public Facility | Total Population (Unit) | Total Sample (Unit) |
|---|---|---|
| Education | 32 | 6 |
| Commercial | 15 | 5 |
| Health centre | 2 | 2 |
| Worship house | 23 | 6 |
| Office | | 1 |
| Street sweeping | | 1 |

Based on Table 1, both of office and street sweeping only take place at one sampling location. The office sample is the government office, Kemayoran Sub District office. Office sample is only one because it is hard to get permission from private offices or big government offices like tax office. Street sweeping takes placed at Indrapura Street. Its length is 700 m.

### Sample of composition, generation and reduction of non residential solid waste

The sampling procedure of composition and generation of solid waste is based on the National Standardization Institution. Non-residential solid waste composition classified into 10 categories. They are food waste; plastic; paper; glass; wood; textile; rubber; metal; diapers and tissue;

and other waste. Non-residential solid waste generation measured before solid waste reduction in every public facility.

A sampling of non-residential solid waste reduction was done by measuring solid waste mass that will be recycled. Existing reduction measurement was done in the source and transfer station (TPS). Source reduction is reduction activity that occurs in public facilities. Source reduction was done mostly by cleaning service, but the solid waste reduction in source is not always happened in every public facility. The existing reduction in the transfer station was done by collecting officers.

Interview with public facility management was done to know existing non-residential management in public facility, so it's important to determine the respondent sample. Total respondent sample calculated with slovin equation. In Slovin equation, user can determine error tolerance . Equation 2 shows respondent calculation in this study. This study use 10% as error tolerance. Slovin equation also used in other study to determine simple random sample [6].

$$N = N / (1 + N \times e^2) \tag{2}$$

Explanation

n     = total respondent sample

N     = total population

e     = error tolerance

n     = 75 units / (1 + 75 units x 0,12)

      = 43 respondets

**Mapping of transfer station**

Krembangan District has 7 transfer stations. Those are Mbah Ratu 3R Transfer Station, Krembangan Selatan Transfer Station, Brimob Transfer Station, Dupak Bandarejo Transfer Station, Dupak Bangunsari Transfer Station, Tanjung Sadari Transfer Station, and Tambak Asri Transfer Station. The purpose of transfer station mapping is to know the percentage of public facilities collecting service. Transfer station mapping was done by making a list of solid waste served by Krembangan District transfer stations. Transfer station mapping was done in every transfer station in Krembangan District for 3 days. This mapping can show unpredictable solid waste generation, such as solid waste from mess, prison, drainage sludge until bulky items like a broken sofa.

**RESULT**

**Generation and composition of non residential solid waste in krembangan districts**

A sampling of non-residential solid waste generation from 21 samples and from transfer station mapping used to calculate total generation of non-residential solid waste. Data about total students, wide of public facilities, total hotel rooms, office employees, and lengths of the street are used to calculate the total generation of non-residential solid waste in Krembangan District. Table 2 shows total generation of solid waste.

Table 2. Total Generation of non residential solid waste in Krembangan District

| Public facilities | Solid waste generation (kg/day) |
|---|---|
| Education: | |
| -Elementary school | 301,83 |
| -Junior high school | 342,80 |
| -Senior high school | 293,22 |
| Office | 1.794,13 |
| Commercial | |
| -Minimarket | 72,47 |
| -Market | 4.609,96 |
| -Restaurant | 313,50 |

| Public facilities | Solid waste generation (kg/day) |
|---|---|
| -Hotel | 437,47 |
| Health centre | |
| -Hospital | 18,53 |
| -Puskesmas | 52,50 |
| Worship house | |
| -Mosque | 75,05 |
| -Chuch | 48,53 |
| -Pura | 4,90 |
| -Pagoda | 1,80 |
| Street swepping | 725,61 |
| Other facility | |
| -Pengadilan negeri prison | 258,75 |
| -Kodim dormitory | 362,25 |
| -Brimob dormitory | 251,00 |
| -Police dormitory | 251,46 |
| Total | 10.179,74 |

Based on Table 2, total non-residential solid waste from Krembangan District is 10.179,74 kg/day or 10,179 ton/day. Other research about non-residential solid waste in Wonokromo Districts about 10,6 ton/day [7]. Comparison with other non-residential solid waste in Wonokromo Districts, there is less difference. Reduction potential analysis will need solid waste recovery factor and solid waste composition. Solid waste can be recycled based on its kind. Figure 1 shows the result of non-residential solid waste composition.
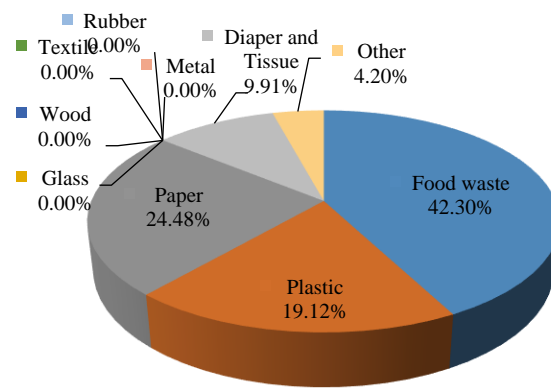


(a)



(b)



(c)



(d)

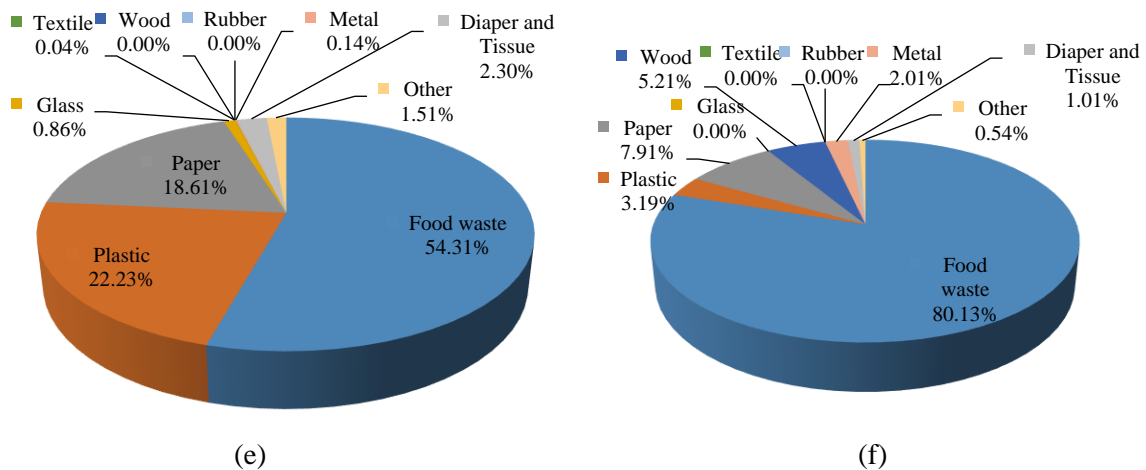(e)                                                        (f)
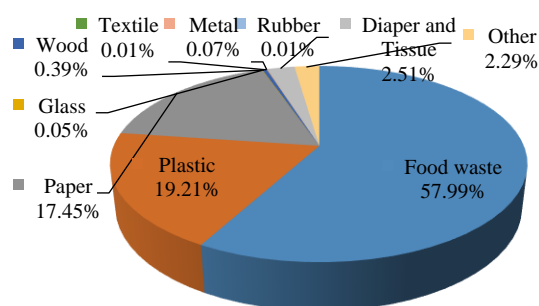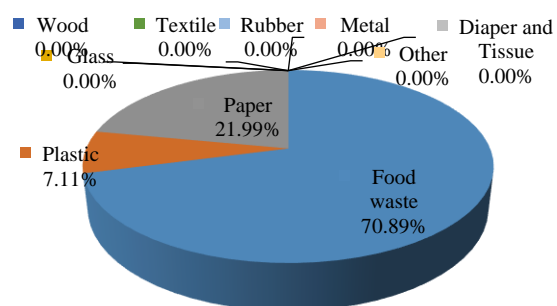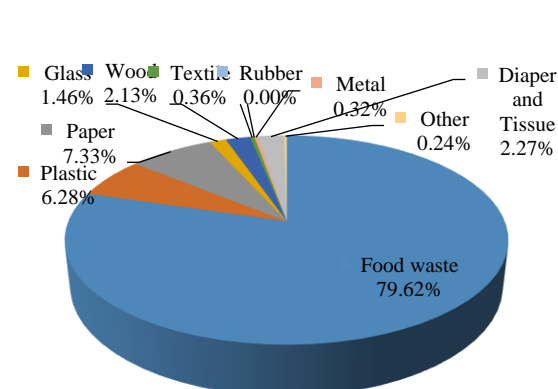
Figure 1 Percent by weight of solid waste composition from public facilities: (a) education; (b) office; (c) commercial; (d) health centre; (e) worship house; (f) street sweeping

Based on figure 1, the food waste component has the largest percentage among other components from all public facilities. The percent by weight of food waste mostly more than 50%. Street sweeping has the highest percentage of food waste composition, that is 80,13%. Other study about solid waste composition from education facility in Indonesia shows that 27,74% as food and garden waste [8]. Municipal solid waste composition in The United State consist of 15% food waste, 27% as paper and many more [9].

**Non residential solid waste mapping in krembangan district transfer stations**

Pattern of non residential solid waste collecting system in Krembangan District based on Indonesia national standard included into 2 types, they are direct individual pattern and indirect individual pattern [10]. Most public facilities in Krembangan District use indirect individual pattern, which is their solid waste collected first into the transfer station and then it transfers into landfill. Transfer station mapping was done by making a list of non-residential solid waste collecting and solid waste generation that produced from other districts.

Transfer station mapping was done in 7 transfer stations in Krembangan District, every transfer station was mapping for 3 days. Transfer station mapping can shows collecting service area and percentage of collecting service. Transfer stations in Krembangan District also serve solid waste collecting system from another districts that near Krembangan Districts such as Asem Rowo District, Pabean Cantian District and Bubutan District. Table 3 shows non residential solid waste generation and solid waste from other district that served by Transfer Stations in Krembangan District.

Table 3. Total Generation of non residential solid waste in Krembangan District

| Transfer Station | Non Residential Solid Waste Generation (kg/day) | Solid Waste Generation From Other District (kg/day) |
|---|---|---|
| Tanjung Sadari | 1629,44 | 279,73 |
| Mbah Ratu | 2.537,58 | 2.607,34 |
| Brimob | 460,08 | 0,00 |
| Krembangan Barat | 2.679,04 | 1.221,69 |
| Tambak asri | 721,70 | 407,93 |
| Dupak Bangun Sari | 814,20 | 341,13 |
| Dupak Bandar Rejo | 710,50 | 0,00 |
| Total | 9.552,53 | 4.857,82 |

117

Based on Table 3, Non-residential solid waste generation in transfer stations is 9.552,53 kg/day, but total non-residential solid waste in Krembangan District is 10.179,74 kg/day. It means the percentage of non-residential collecting service is 93,8%. Collecting service percentage does not reach 100% because there are some public facilities that collect their solid waste into other transfer stations which are not located in Krembangan Districts, such as Krembangan Selatan Puskesmas throw their solid waste into a transfer station in Paben Cantian District and many other public facilities. Generation of solid waste that produced from another district is 4,857 ton/day.

**Exsisting reduction of non residential solid waste in source and transfer station**

There isn't a public facility in Krembangan District that does composting for solid waste reduction activity. Non-residential solid waste reduction activity is only with recycling. The existing reduction of non-residential solid waste was done in the source and transfer station. Source reduction was done mostly by cleaning service, but the reduction in source is not always happened in every public facility. Table 4 shows the result of the existing reduction in source and transfer station. Figure 2 shows the mass balance of non-residential solid waste in existing reduction.
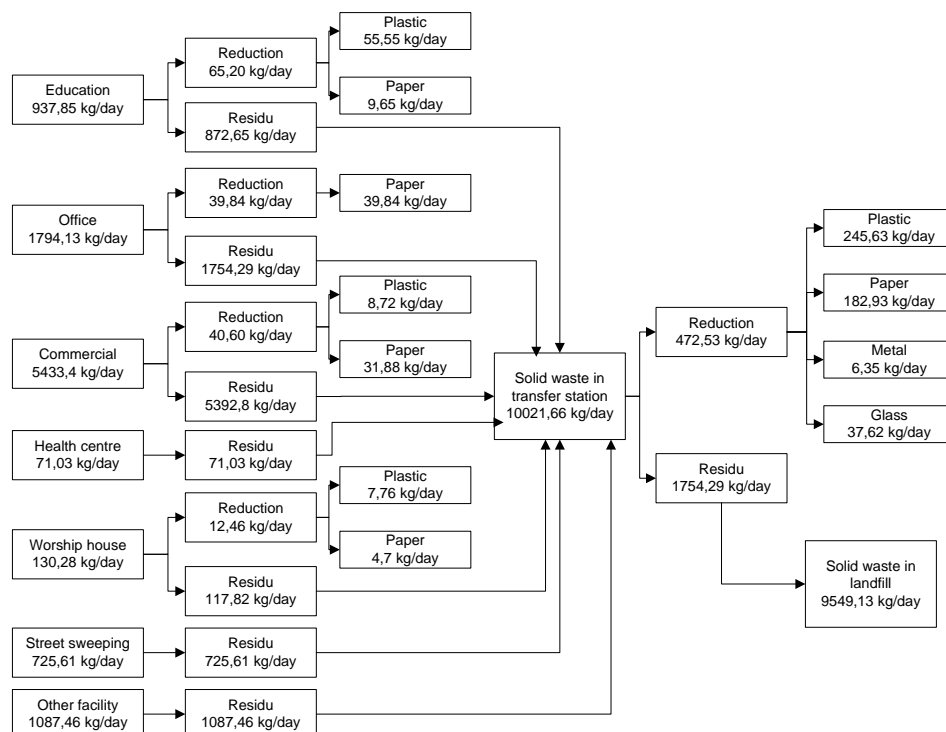


Figure 2 Mass balance of non residential solid waste in existing reduction

Based on Table 4, total existing reduction of non residential solid waste in Krembangan District is 630,63 kg/day or 6,19 % from total solid waste. Compare with other research about non residential solid waste in Simokerto District Central Surabaya, existing reduction in source is 3,69% and in transfer station is 10,81% [11]. It means the total existing reduction of non-residential solid waste in Krembangan district is lower than Simokerto Districts, so the reduction can be increased but must consider reduction potential.

Table 4 Existing reduction in source and transfer station

| Public Facilities | Existing reduction (kg/day) | |
|---|---|---|
| | Source | Transfer station |
| Education | 65,19 | 57,07 |
| Office | 39,84 | 267,31 |

| Public Facilities | Existing reduction (kg/day) | |
|---|---|---|
| | Source | Transfer station |
| Health service | 0,00 | 12,42 |
| Commercial | 40,60 | 60,75 |
| Worship house | 12,46 | 14,45 |
| Street Sweeping | 0,00 | 0,00 |
| Other facilities | 0,00 | 60,53 |
| Total | 158,1 | 472,53 |

**Reduction potential of non residential solid waste**

The reduction potential of non-residential solid waste is based on the recovery factor of non-residential solid waste. Recovery factor is a percentage of solid waste that can be recycled [12]. Recovery factor is founded by observation of non-residential solid waste composition and interview. Reduction activities that can reduce solid waste generation are composting and recycling, so reduction potential was calculated with both of that activities.

Composting can reduce food waste up to 54% [13]. Food wastes of public facilities that have the potency to compose are from school, street sweeping, and market. It because food waste from school, street sweeping, and market have the heaviest among other public facilities. Equations 3 and 4 show how to calculate the percentage of food waste reduction with composting from school non-residential solid waste. The value of solid waste composition can be shown in figure 1. Food waste reduction from street sweeping and market are calculated based on equations 3 and 4 shows in Table 5

$$\text{Food waste reduction (kg)} = (\%\text{food waste composition x total school solid waste generation}) \times \% \text{ recovery factor} \qquad (3)$$

$$= (57,99\% \times 937,85 \text{ kg/day}) \times 81,01\% = 440,58 \text{ kg/day}$$

$$\%\text{composting} = \frac{\text{food waste reduction}}{\text{school solid waste}} \times 100\% \qquad (4)$$

$$= \frac{440,58}{937,58} \times 100\% = 46,98\%$$

Table 5. Reduction Potential of composting based on recovery factor

| Public facility | Solid waste generation (kg/day) | Percentage of recovery factor (%) | Food waste reduction (kg/day) | Percentage of composting reduction (%) |
|---|---|---|---|---|
| Education | 937,85 | 81,01 | 440,58 | 46,98 |
| Market | 4.609,96 | 67,86 | 2741,66 | 59,47 |
| Street sweeping | 725,61 | 87,05 | 506,07 | 69,74 |
| Total Food waste reduction (kg/day) | | | 3688,31 | |

Based on Table 4, if food waste from education, street sweeping, and market used optimally, it will reduce 3688,31 kg/day. Non-residential solid waste can be reduced not only with composting but also with recycling activity. Recycling activity is a process that includes collecting, separating, and selling solid waste material that still has a selling price. Some public facilities have recycled their non-residential solid waste. Based on interviews with every public facility, they only want to recycle paper and plastic. Some public facilities don't want to recycle both of plastic and paper.

Kind of paper that can be recycled are old newspaper, office paper, cardboard and other kind of paper. Dirty and wet paper can't be sold. Percentage of paper waste recycling in Indonesia up to 70% [14]. Plastic is divided into 7 categories, they are Polyethylene terephthalate (PETE), High Density Polyethylene (HDPE), Polyvinyl Chloride (PVC), Low Density Polyethylene (LDPE),

Polypropylene (PP), Polystyrene (PS) and Other. Polystyrene (PS) and other categories usually can't be sold. Plastic waste can be recycled and process into plastic pellets with melting process [15].

The example of non residential solid waste calculation with recycling activity show in equation 5 and 6. Equation 5 and 6 show about reduction potential of paper recycling based on recovery factor from education solid waste. Value of paper and plastic waste composition can be shown in figure 1. Solid waste reduction potential with recycling calculated for all public facilities and it can be shown in Table 5.

paper reduction (kg)= (%paper composition x total school solid waste generation) x % recovery

$$\text{facto} \qquad (5)$$

$$= (19{,}21\% \text{ x } 937{,}85 \text{ kg/day}) \text{ x } 53{,}87\% = 97{,}06 \text{ kg/day}$$

$$\% \text{ recycling } = \frac{\text{paper reduction}}{\text{school solid waste}} \text{ x } 100\% \qquad (6)$$

$$= \frac{97{,}06}{937{,}58} \text{ x } 100\% = 10{,}35\%$$

Table 6. Reduction Potential of composting based on recovery factor

| Public facility | Solid waste generation (kg/day) | Percentage of recovery factor (%) | Recycling reduction (kg/day) | Percentage of recycling reduction (%) |
|---|---|---|---|---|
| Education | | | | |
| -Plastic | 937,85 | 53,87 | 97,06 | 10,35 |
| -Paper | 937,85 | 52,44 | 85,82 | 9,15 |
| Office | | | | |
| -Paper | 1794,13 | 59,27 | 233,9 | 13,04 |
| Minimarket | | | | |
| -Paper | 72,47 | 64,93 | 7,38 | 10,19 |
| Market | | | | |
| -Plastic | 4609,96 | 21,71 | 64,39 | 1,4 |
| -Paper | 4609,96 | 83,8 | 76,47 | 1,66 |
| Hotel | | | | |
| -Plastic | 437,47 | 43,72 | 23,95 | 5,47 |
| -Paper | 437,47 | 50,02 | 35,6 | 8,14 |
| Restaurant | | | | |
| -Plastic | 313,5 | 54,76 | 4,13 | 1,32 |
| -Paper | 313,5 | 53,58 | 9,22 | 2,94 |
| Health Service | | | | |
| -Plastic | 71,02 | 61,2 | 8,31 | 11,7 |
| -Paper | 71,02 | 51,18 | 8,9 | 12,53 |
| Woship house | | | | |
| -Plastic | 130,28 | 77,07 | 22,32 | 17,13 |
| -Paper | 130,28 | 71,01 | 17,22 | 13,22 |
| Total recycling reduction (kg/day) | | | 694,67 | |

Recovery factor range for plastic and paper waste is 70%-90% [16], recovery factor for plastic and paper waste from this study between 20%-78%. Based on Table 5, if every public facility does paper and plastic reduction optimally based on recovery factor, it can reduce 694,67 kg/day. Information about solid waste component that can be recycled got from informal sector who do recycling activities. Based on Table 4 and Table 5, total reduction potential based on recovery factor is 4.382,98 kg/day. It means if every public facilities want to reduce their non residential solid waste

optimally, it will reduce 43,05% from total residential solid waste generation. Figure 3 shows mass balance of non residential solid waste reduction based on recovery factor
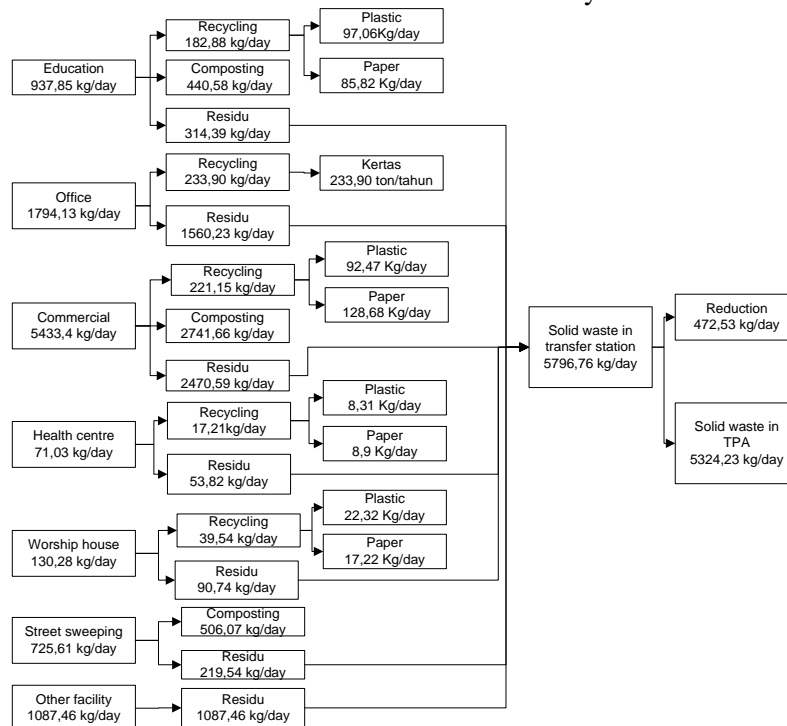


Figure 3 Mass balance of non residential solid waste reduction based on recovery factor

**Factors that influence public facilities participation**

Existing reduction of non residential solid waste is 637,04  kg/day. Non residential solid waste that produced from public facilities in Krembangan District have potential to reduce until 4362,98 kg/day. There is big different between existing reduction and reduction potential, it because of participation of public facilities. These are factors that influence public facilities participation:

1.  Public facility knowledge
    Knowledge about solid waste management such as separation and reduction for public facility management is important. Education facilities do separation and reduction more often than commercial facility. It because education management more familiar with solid waste management knowledge.
2.  Public facility awareness
    Some commercial facility such us hotel restaurant management understand about solid waste management such separation and reduction but they don't want do it.
3.  Busy activity in public facility
    Busy activity that happened in public facility is to be main reason for low public facilities participation. It's hard getting time for public facilities management do reduction activity such as composting.
4.  Low profit
    In existing condition, there is no public facility do composting activity routinely, only education facility do composting more often than other public facilities. Composting only has low profit and it' doesn't appropriate with composting effort.

**CONCLUSION**

Based on result data and discussion, the conclusions of this research are total non-residential solid waste generation in Krembangan District is 10,18 ton/day; total existing reduction of non-residential

solid waste is 637,04 kg/day or 6,27 %. It means national target about solid waste reduction up to 20% has not reached yet; reduction potential with composting and recycling activities are 3.668,31 kg/day and 694,67 kg/day.

## REFERENCES

[1]     H. K. Kurniawan, "Studi Deskriptif Strategi Public Private Partnership Pengelolaan Sampah Di TPA Benowo Kota Surabaya," *Kebijak. dan Manaj. Publik*, vol. 4, pp. 210–219, 2016.

[2]     P. R. Indonesia, *Peraturan Pemerintah Republik Indonesia Nomor 81 Tahun 2012 Tentang Pengelolaan Sampah Rumah Tangga Dan Sampah Sejenis Sampah Rumah Tangga*. 2012.

[3]     P. K. Surabaya, *Peraturan Daerah Kota Surabaya nomor 12 Tahun 2014 Tentang Rencana Tata Ruang Wilayah Kota Surabaya Tahun 2014-2034*. 2014, pp. 1–172.

[4]     Pemerintah Republik Indonesia, *Peraturan Presiden Republik Indonesia Nomor 97 Tahun 2017 tentang Kebijakan Dan Strategi Nasional Pengelolaan Sampah Rumah Tangga Dan Sampah Sejenis Sampah Rumah Tangga*. 2017, pp. 1–15.

[5]     B. S. Nasional, *SNI 19-3964-1994 Metode pengambilan dan pengukuran contoh timbulan dan komposisi sampah perkotaan*. 1994.

[6]     Ansar, A. Lukum, Arifin, and Y. J. Dengo, "The Influence of School Culture on The Performance of High School English Teachers in Gorontalo Province," *Int. J. Educ. Res.*, vol. 5, no. 10, pp. 35–48, 2017.

[7]     Febri Ayu Sasmita and Warmadewanthi, "Studi Pengumpulan Sampah Sejenis Sampah Rumah Tangga di Kecamatan Wonokromo , Surabaya Selatan," vol. 4, no. 1, 2015.

[8]     Y. Dewilda and J. Julianto, "Kajian Timbulan, Komposisi, dan Potensi Daur Ulang Sampah Sebagai Dasar Perencanaan Pengelolaan Sampah Kawasan Kampus Universitas Putra Indonesia (UPI)," *Semin. Nas. Pembang. Wil. dan Kota Berkelanjutan*, vol. 1, no. 1, pp. 142–151, 2019, doi: 10.25105/pwkb.v1i1.5270.

[9]     H. I. Abdel-Shafy and M. S. M. Mansour, "Solid waste issue: Sources, composition, disposal, recycling, and valorization," *Egypt. J. Pet.*, vol. 27, no. 4, pp. 1275–1290, 2018, doi: 10.1016/j.ejpe.2018.07.003.

[10]    E. Damanhuri and T. Padmi, *DIKTAT KULIAH TL-PENGELOLAAN SAMPAH*. INSTITUT TEKNOLOGI BANDUNG, 2010.

[11]    A. F. Muhammad, *Studi Pengumpulan Sampah Sejenis Sampah Rumah Tangga di Kecamatan Simokerto, Surabaya Pusat*. Jurusan Teknik Lingkungan, Fakultas Teknik Sipil dan Perencanaan, Institut Teknologi Sepuluh Nopember, 2015.

[12]    G. Tchobanoglous, H. Theisen, and S. A. Vigil, *Integrated Solid Waste Management*. New York: Mc Graw- Hill, 1993.

[13]    J. K. Andersen, A. Boldrin, T. H. Christensen, and C. Scheutz, "Mass balances and life cycle inventory of home composting of organic waste," *Waste Manag.*, vol. 31, no. 9–10, pp. 1934–1942, 2011, doi: 10.1016/j.wasman.2011.05.004.

[14]    F. L., Sahwan, and S. Wahyono, "BERBASIS MASYARAKAT Studi Kasus di Kampung Banjarsari , Cilandak - Jakarta Selatan," pp. 7–12.

[15]    I. H. Pratiwi, S. Wignjosoebroto, and S. Dewi, "Pendekatan Ergonomi Total Guna Meningkatkan Peran Serta Masyarakat ( Studi Kasus : Surabaya )," 2008.

[16]    G. Tchobanoglous and F. Kreith, *Handbook of Solid Waste Management*, Second Edi. New York: Mc Graw- Hill, 2002.