

# Community activities in residential solid waste reduction in Tenggilis Mejoyo District, Surabaya City, Indonesia

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**Abstract** The main source of municipal solid waste in Indonesia is residential area. The Indonesian Government Regulation No. 81/2012 concerning Residential Solid Waste (RSW) Management and Similar Types of Solid Waste stipulates that every generator is obliged to perform separation and treatment. This study was aimed to determine RSW generation rate, reduction potential, and reduction activities by the community in Tenggilis Mejoyo District, Surabaya City. The RSW generation rate and composition were measured according to ASTM D5231-92 method. RSW reduction potential was determined based on weight percentage of recyclable RSW components. This study involved 100 householders, who were selected using stratified random approach based on the economical strata. This study resulted in RSW generation rate of 0.29 kg/person day, or a total of 16.84 tons/day. The RSW composition was dominated by biodegradable organics of 74.43 %, followed by plastic and paper waste materials. Estimated RSW reduction potential was 67.92 %. The RSW separation was only done by 37 % of respondents. Main reasons of the respondents for not implementing RSW separation were inavailability of time, laziness, and no use. Composting activity was conducted by 17 % respondents. This research further provides a

recommendation for improving community participation in RSW reduction.

**Keywords** Community activities · Reduction · Residential solid waste

## Introduction

The rapid population and industrial growth in Surabaya City has caused the municipal solid waste (MSW) generation to increase. Surabaya City generates 1689 tons MSW per day with the population of 3,104,584 [1, 2]. JICA study in 2008 showed that the MSW collection rate in Java was only 59 % [3]. A study by Puspitarini et al. in 2013 showed that the MSW collection rate in East Surabaya achieved 82.5 % [4]. About 79.19 % of MSW in Surabaya City was generated from the residential area. The Living Environment Board of Surabaya City estimated that the residential areas generated more than 1200 tons of solid waste (SW) per day [5]. However, this city should face limited resources for implementation of proper MSW management, such as inadequacies in service provision, financing, environmental controls, institutional structure, understanding of complex systems, and sanitation [6]. Therefore, the reduction of solid waste at source was considered as the most appropriate strategy for managing the MSW [7]. In order to implement this strategy, community participation was generally recommended in solid waste management in developing countries [8].

The sustainability of solid waste management system can be achieved with the establishment of community awareness program for conducting solid waste reduction, separation, and recycling [9]. The economical status of people and community behavior may affect solid waste

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reduction activities at source [10]. Accordingly, the lack of knowledge and facilities could inhibit community participation in conducting the solid waste reduce, reuse, and recycle (3R's) program. Some people might state that they had limited time to involve in solid waste reduction and space for providing treatment facilities [11]. Intensive social approach could maintain community participation in implementing proper solid waste separation and reduction activities [7]. Additionally, the sustainability of 3R's activities can be promoted if markets of solid waste treatment products are available [11].

Reformation on community behavior in MSW management in Surabaya City was begun in 2001, when the only one open dumped disposal site at Keputih District was closed by the communities due to the offensive environmental impacts. Since then, the communities were intensively introduced with community awareness and solid waste treatment technology, and the provision of household and communal composting facilities by the municipality and the Non-Governmental Organizations (NGOs). The women association of the municipality routinely organized solid waste reduction awareness program for householders. Introduction of solid waste treatment options covered compost making and handcraft production from plastic waste materials [12].

Paper and metal waste components were generally stored by the householders, and sold to the recyclable waste collectors in Surabaya City [13]. The Living Environment Board of Surabaya City reported that the MSW reduction in 2012 was implemented with community involvement. The community activities are expected to include separation, recycling, and marketing of the recyclables and composting of biodegradable solid waste. Reduction of the Residential Solid Waste (RSW) was also supported with the construction and operation of compost houses, which were built in several communities [5]. Eighteen compost houses could treat 42–147 m<sup>3</sup> of residential yard waste every day [14].

Another RSW reduction facility that has been operated in Surabaya City is solid waste bank (SWB). The solid waste bank system is defined by the Department of Public Works as a collective and systematic management option of recyclable and decomposable solid waste materials from the generators [15]. This facility serves community saving activity, which uses recyclable solid waste as saving materials. The recyclable solid waste from each generator is weighed for further collectively and systematically managed. The economical value is calculated, saved, and reported to the solid waste generator. This mechanism can force the community to sort and to value the solid waste [16]. According to the Mayor of Surabaya City, 180 solid waste banks have been operated since 2014, with estimated total number of customers more than 10,000 [17].

Another effort for reducing the solid waste by the municipality is the provision of trained environment cadres. Selected volunteers from every district were trained by the municipality or NGOs. Their duty is to give personal assistance to the householders in RSW reduction. About 28,000 environment cadres had been trained for serving all communities in Surabaya City [18, 19].

In addition to the above-mentioned efforts for solid waste reduction, the use of "Takakura" composting basket was introduced for treating the RSW biodegradable part in 1990s. Introduction of Takakura was done when the partnership program between The Japan's Kitakyushu International Techno-cooperative Association (KITA) and Surabaya Municipality took place. Seventeen thousand units of Takakura baskets were distributed to the local communities through the NGOs. Maeda reported that only 20 % of the communities continued practicing the Takakura method in Surabaya City [20]. The Takakura program failed because the follow-up system was not prepared well. There were limitations in terms of expansion and scale because the program was handled only by NGOs [21]. Therefore, it is very interesting to perform this study in Surabaya City, in order to evaluate how the communities involved in reducing the solid waste after various efforts have been introduced.

This paper aimed to measure RSW generation rate, reduction potential and to describe the community activities in RSW reduction program. Tenggilis Mejoyo District was selected as the study area from a total of 31 districts in Surabaya City for some seen activities in RSW 3R's by the community and for the varied economic levels of the householders. Being inhabited by 58,058 people of 16,024 householders, this district consists of 5 subdistricts and occupies an area of 5.51 km<sup>2</sup> [22]. The State Regulation No. 81/2012 concerning the Management of RSW and Similar Types of Solid Waste stipulates that every citizen and the managers of residential areas are obliged to conduct solid waste separation and treatment [23]. The results of this research are meant to reveal how the RSW 3R's program be implemented by the community in the study area, after 13-year introduction of community involvement in RSW reduction in Surabaya City.

## Method

The RSW generation rate and composition were measured from household samples. The number of householder samples was determined using Slovin's equation [24, 25]. The estimation error which was used in this research was 10 %. The Slovin's equation resulted in 100 households for survey implementation. Stratified random sampling method was applied to determine the number of household samples

from different economic strata, which were then combined into a single sample [26]. The economical strata were determined according to annual land and building ownership tax, which was paid by each householder. The low income, middle income, and high income groups of tax were classified into three categories, namely: less than Indonesian Rupiah (IDR) 100,000; between IDR 100,000 and IDR 300,000; and higher than IDR 300,000 respectively. These tax categories were used to replace the income levels of the respondents. One of the reasons of using the tax category was that the householders were not open to give open information concerning their income.

This classification resulted in the following numbers of household samples of each stratum: 16 from the low economical stratum, 27 from the middle stratum, and 57 from the high stratum. Tenggilis Mejoyo District comprises five subdistricts, namely Panjang Jiwo, Prapen, Tenggilis Mejoyo, Kendangsari and Kutisari. The household samples were proportionally distributed and selected in these subdistricts. A total of 16 householders were selected in Panjang Jiwo subdistrict, 7 in Prapen, 18 in Tenggilis Mejoyo, 25 in Kendangsari, and 34 in Kutisari. The total number of family members in all householder samples was 469.

RSW samples for generation rate and composition measurement were collected from the selected householders. Each householder was provided with one plastic bag for placing the RSW, which was generated in 24 h. Collection of the RSW samples was done on the next day. Measurements of RSW generation rates and compositions were done according to Standard Test Method for Determination of the Composition of Unprocessed Municipal Solid Waste ASTM D5231-92 [27]. Replication was done in eight consecutive days in order to cover daily fluctuation (which included weekdays and weekends) of the RSW generation rate. This method has been formally used as national standards for measuring MSW generation rate and composition in Indonesia to date [28].

A survey was conducted to the similar selected householder samples as described earlier for determining community perceptions, activities and willingness in implementing the 3R's activities. During the survey, the respondents were interviewed by a surveyor using questionnaires, which were of closed questions with fixed options of answers. The data were tabulated for analysis.

Chi-squared ( $\chi^2$ ) correlation test was performed using SPSS software of 18th version in order to determine correlations between the predictor variables and the respond variables. The respond variables covered three categories of community activities, each of which was provided with two nominal scales as the following:

1. Sorting the RSW (Y1): respondent activity in separating the RSW into decomposable and non-

decomposable materials. Y1 = 0, if respondent did not do the sorting; Y1 = 1, if respondent did the sorting.

2. Recycle the non-decomposable RSW (Y2): respondent activity in handcraft making from recyclable materials. Y2 = 0, if respondent did not do the handcraft making; Y2 = 1, if respondent did the handcraft making.
3. Produce compost (Y3): respondent activity in producing compost from decomposable RSW material. Y3 = 0, if respondent did not do composting; Y3 = 1, if respondent did composting.

The predictor variables are listed in Table 1.

Correlations among the respond variables and predictor variables were determined using the following hypotheses:

1.  $H_0$  is accepted: if there is no correlation between the respond variables (Y) and the predictor variables (X);
2.  $H_1$  is accepted: if there is correlation between the respond variables (Y) and the predictor variables (X).

Correlations between the predictor and respond variables were determined according to the significance values ( $\alpha$ ) and Pearson  $\chi^2$  values.

The correlation test between the predictor and respond variables was done as follows:

1. The predictor variable is correlated with the respond variable if the calculated  $\alpha$  value was lower than 0.1, or the calculated Pearson  $\chi^2$  value was higher than  $\chi^2$  value in table (reject  $H_0$  and accept  $H_1$ ).
2. The predictor variable is not correlated with the respond variable if the calculated  $\alpha$  value was higher than 0.1, or the calculated Pearson  $\chi^2$  value was lower than  $\chi^2$  value in table (accept  $H_0$  and reject  $H_1$ ).

## Results and discussion

### RSW generation rate

The results showed that the RSW generation rate ranged from 0.27 to 0.33 kg/person day during the 8-day measurement, with an average of 0.29 kg/person day (Table 2). Based on this value, the total RSW generation rate in Tenggilis Mejoyo District with a population of 58,058 inhabitants was 16.84 tons/day. In this research the measurement of RSW generation rates of different economic strata of the generators were not differentiated. The RSW samples from the three different economical strata were mixed prior to generation rate measurement in order to obtain a single generation rate which represented the study

**Table 1** List of predictor variables and scale of each variable

No.	Predictor variables	Scale
1	Economical strata of the respondent based on annual property and tax category (X1)	
	Low (tax category of <IDR 100,000)	1
	Middle (tax category of IDR 100,000–300,000)	2
	High (tax category of >IDR 301,000)	3
2	Knowledge in sorting (X2)	
	No knowledge	1
	Sufficient knowledge	2
3	Knowledge in composting (X3)	
	No knowledge	1
	Sufficient knowledge	2
4	Knowledge in greenhouse gases (X4)	
	No knowledge	0
	Sufficient knowledge	1
5	Knowledge in effect of solid waste to green house gas emission (X5)	
	No knowledge	0
	Sufficient knowledge	1
6	Availability of solid waste bank (X6)	
	Not available	0
	Available	1
7	Availability of composting facilities (X7)	
	Not available	0
8	Training program on 3R (X8)	
	Not available	0
9	Availability of information concerning 3R from mass media (X9)	
	Not available	0
10	Existence of environment cadre (X10)	
	Does not exist	0
	Exists	1

area. Earlier studies showed that one of the factors which affected the generation rate of household solid waste was the income levels of the generators. The high-income group generated RSW with highest rate, and lowered in the middle towards the low-income groups [29, 30].

### RSW composition and reduction potential

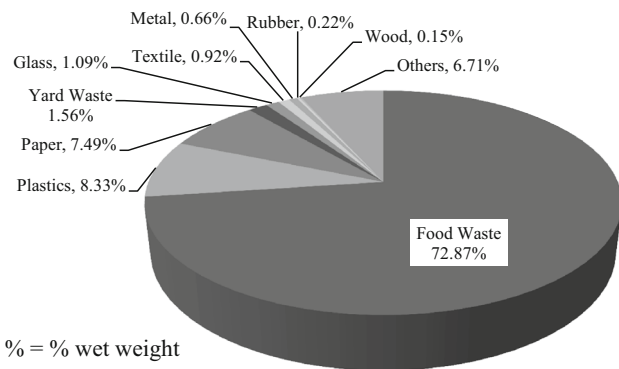
The RSW was dominated by food waste (72.87 %), followed by plastics (8.33 %), paper (7.49 %), and other components in smaller proportions (Fig. 1). Paper, plastics, and metal waste components were the most preferred materials for separation by the generators to be sold to waste collectors. The reduction potential of the RSW was estimated by using recovery factor values of each solid

waste component as described by Tchobanoglous et al. and Trihadiningrum et al. [31, 32]. Solid waste recovery factor or recovery rate is defined as the weight percentage in wet basis of solid waste which is separated for reuse or recycling [31, 33].

The estimated RSW reduction potential values in Tenggilis Mejoyo District are shown in Table 3. Food waste has a recovery factor of 80 %. This means that 80 % of food waste can be potentially treated as raw material for compost or biogas production. The remaining 20 % should be disposed of as residual matter. As shown in Table 3, if the 3R's program worked effectively, the RSW could be potentially reduced up to 11.46 tons/day (68.05 %), leaving 5.38 tons (31.95 %) of residual components for final disposal. This reduction potential could be achieved if all

**Table 2** Results of RSW generation rate measurement in Tenggilis Mejoyo District

Day	Number of householder samples	Number of family members (a)	RSW weight (kg) (b)	RSW generation rate (kg/person day) (b)/(a)
1	100	469	133.80	0.29
2			127.00	0.27
3			125.00	0.27
4			146.90	0.31
5			152.50	0.33
6			132.00	0.28
7			130.70	0.28
8			135.40	0.29
Average				0.29



**Fig. 1** RSW composition in Tenggilis Mejoyo District

householders were willing to do RSW separation and treatment activities.

**Community activities in RSW separation**

Community activities in RSW separation include sorting the recyclable materials, such as paper, plastics, and metals

from decomposable and residual components. Among 100 respondents being surveyed by direct interview, 37 % separated and collected the recyclable RSW components for further treatment. The other 63 % did not do this activity. Sixty percents of those who did not do the RSW separation stated that they were willing to do the RSW separation in the future, and the other 40 % refused to do this activity (Fig. 2).

From five reason options being questioned to respondents who did RSW separation during the survey, 41 % stated that self awareness as the reason (Table 4). The other 30 % declared that they did the RSW separation due to community leader instruction. Other respondents (11 %) mentioned that the reasons were as effect of training, and for generating family income (5 %). The remaining 13 % of the respondents mentioned other reasons, such as: following friends, following instruction of the women association, for contributing the sorted materials to neighbors, waste pickers, or local organization.

The reasons of the respondents who did not separate the RSW were: time unavailability (30 %), laziness (17 %),

**Table 3** RSW reduction potential in Tenggilis Mejoyo District

No.	Component	Wet weight (%)	Weight (tons/day)	Recovery factor (% wet weight)	Potential recovered SW component (tons/day)	Potential residual RSW (tons/day)
1	Food waste	72.87	12.27	80 [31]	9.82	2.45
2	Plastics	8.33	1.40	50 [32]	0.70	0.70
3	Paper	7.49	1.26	40 [32]	0.51	0.75
4	Yard waste	1.56	0.26	80 [31]	0.21	0.05
5	Glass	1.09	0.18	70 [32]	0.13	0.05
6	Textile	0.92	0.16	0	0.00	0.16
7	Metal	0.66	0.11	80 [32]	0.09	0.02
8	Rubber	0.22	0.04	0	0.00	0.04
9	Wood	0.15	0.03	0	0.00	0.03
10	Others	6.71	1.13	0	0.00	1.13
Total			16.84		11.46	5.38
Percentage		100.00			68.05	31.95



impracticality (16 %), inefficiency (11 %), no technical knowledge for RSW treatment (8 %), no facility for sorting the RSW materials (5 %), no separate bin facility (5 %), and other reasons (8 %) as shown in Table 5. The highest percentage of respondents declared that they have limited time to participate in RSW separation. Laziness or lack of interest was classified as individual barrier, which sometimes outweighed the environmental concern [34].

Respondents who stated that the RSW separation was inefficient, explained that the RSW collection crew always remixed the separated RSW components when loaded to the collection vehicle. The handcarts and trucks, which served house to house RSW collection, were not facilitated

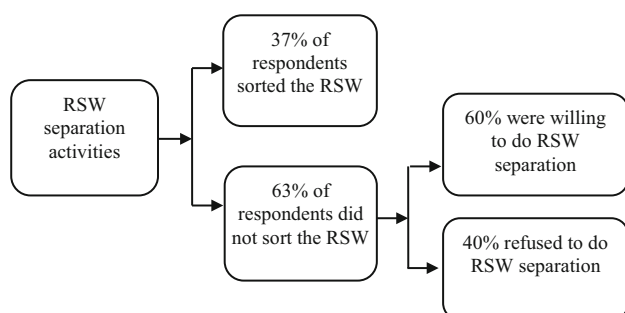


Fig. 2 Community activities in RSW separation

Table 4 Reasons of respondents in performing RSW separation

No.	Reasons	Percentage (%)
1	Self awareness	41
2	Community leader instruction	30
3	Effect of training	11
4	To increase family income	5
5	Other reasons	13
Total		100

Table 5 Reasons of respondents who did not do RSW separation

No.	Reasons	Percentage (%)
1	Unavailability of time	30
2	Laziness	17
3	Impracticality	16
4	Inefficiency	11
5	No technical knowledge for further treatment	8
6	No facility for storage of the sorted RSW materials	5
7	No separate bin facility	5
8	Other reasons	8
Total		100

with a procedure for collecting the sorted RSW components separately. Therefore, all separated RSW components were mixed, when deposited in transfer depots for further transport to the final disposal site. This condition is not favorable for the householders in implementing the RSW separation at source.

One of the policies in Surabaya City is to modify a number of solid waste transfer depots to become 3R’s facilities [35]. These facilities may work well with community involvement if the municipality facilitates appropriate collection vehicles for separated waste components.

**RSW recyclable material handling**

The majority (65 %) of respondents who did RSW separation stated that the recyclable non-compostable waste materials, such as paper, plastics, and metals, were directly sold to recyclable waste collectors (Table 6). This attitude is commonly done by householders in Surabaya City because it is most practicable for additional income generation from the solid waste. Recyclable waste collector is part of informal sector, whose business is as buyer of recyclable solid waste from the generators or solid waste pickers. The waste collector workshops operate throughout Surabaya City and easy to find. The recyclable solid waste is further sold to the agent, whose hierarchy in informal sector is higher than the collectors. The agent performs limited treatment to the recyclable solid waste, such as washing the plastic waste, shredding it into flakes, pelletizing the flakes, and packaging. Such a phenomenon was common in developing countries in Asia, where simple recycling technologies were applied [36]. The treated recyclables are sold to the manufacturing industries [32, 37]. The other 35 % of respondents treated the recyclable waste materials by other means, i.e. contributed to solid waste pickers or to community leader, or saved in the solid waste bank.

This situation indicates that the informal sector plays an important role in handling the recyclable non-compostable RSW materials after segregation by the householders. Visvanathan et al., however, suggested that a more formal promotion, technology transfer, and policy reformulation of 3R’s based solutions were needed for coping with the solid waste problem [36].

Table 6 Treatment of recyclable RSW by the community

No.	Treatment to separated recyclables	Percentage (%)
1	Directly sold to waste collectors	65
2	Treated by other means	35
Total		100

The actual reduction rate of non-compostable waste materials was influenced by the community participation rate of 65 %. This participation rate can be used for estimating the actual reduction rate of these types of RSW materials. The estimated actual recycling amount of non-compostable waste can be calculated using Eq. 1:

$$\begin{aligned} &\text{Estimated actual recycling amount of non-compostable waste} \\ &= \text{community participation factor} \times \text{potential recycling of plastics,} \\ &\quad \text{paper, glass, and metals} \end{aligned} \tag{1}$$

Using Eq. 1, the estimated actual recycling amount of non-compostable waste = 65 % × (0.70 + 0.51 + 0.13 + 0.09) = 65 % × 1.43 tons/day = 0.93 tons/day

The potential recycling amount of these materials was 1.43 tons/day (calculated from data in Table 3). The actual recycling rate of non-compostable waste materials can be calculated using Eq. 2.

$$\begin{aligned} &\text{Estimated actual recycling rate of non-compostable waste materials} \\ &= \frac{\text{Estimated actual recycling rate of non-compostable waste}}{\text{Total amount of the RSW}} \\ &\quad \times 100 \% \end{aligned} \tag{2}$$

Hence, The estimated actual recycling rate of non-compostable waste materials =  $\frac{0.93}{16.84} \times 100 \% = 5.52 \%$

The calculation above shows that the actual recycling rate of non-compostable solid waste materials is low, although the community participation factor is reasonably high. This is because of the low percentages of these materials (plastics, paper, glass and metals) in the RSW. Therefore, the community should focus more on treating the biodegradable solid waste materials.

### RSW treatment

Only 8 % of the respondents made handcraft products, such as home ornament, laptop bags, shopping bags, jackets, and umbrellas, from plastic waste materials. The reasons for the low participation of handcraft making were the low generation rate of plastic waste material (50 %), the limited number of markets for the products (25 %), and the lacks of human resource (25 %). These activities were done either by individual (62 %) or communal (38 %).

The biodegradable organic waste was composted by only 17 % of respondents. This community participation value can be used for estimating the actual composting rate. The estimated actual recycling amount of biodegradable RSW can be calculated using the following equation:

$$\begin{aligned} &\text{Estimated actual recycling amount of compostable waste} \\ &= \text{community participation factor} \\ &\quad \times \text{potential recycling of food waste and yard waste} \end{aligned} \tag{3}$$

Using Eq. 3, the estimated actual recycling amount of compostable waste = 17% × (9.82 + 0.21) = 17 % × 10.03 tons/day = 1.70 tons/day

The potential recycling amount of these materials was 10.03 tons/day (calculated from data in Table 3). The actual recycling rate of compostable waste materials can be calculated using Eq. 4.

$$\begin{aligned} &\text{Estimated actual recycling rate of compostable waste materials} \\ &= \frac{\text{Estimated actual recycling rate of compostable waste}}{\text{Total amount of the RSW}} \times 100 \% \end{aligned} \tag{4}$$

Hence, the estimated actual recycling rate of compostable waste materials =  $\frac{1.70}{16.84} \times 100 \% = 10.09 \%$ .

The low actual value of recycling rate of compostable RSW material revealed that the community in the study area had not played a significant role in treating the biodegradable waste. The reasons stated by 83 % of the respondents who did not do composting activities were: unavailability of time (39 %), no technical knowledge (30 %), laziness (14 %), and the other reasons (17 %). The other reasons were: unavailability of space, health factor, insight factor, and lack of guidance. Fifty-three percent (53 %) of the respondents, who composted the biodegradable waste, made compost from the yard waste. The other 29 % composted combined yard waste and food waste, and only 18 % of the respondents composted food waste.

### Correlations between the respond variables and the predictor variables

The calculated Pearson  $\chi^2$  values were compared to the values in  $\chi^2$  table at a significance level of 0.1, and degrees of freedom of 1 and 2. The used values of  $\chi^2$  from the table were  $\chi^2(1:0.10) = 2.706$  and  $\chi^2(2:0.10) = 4.605$ . The results of  $\chi^2$  correlation test on community sorting, composting and treating the recyclable component activities with the predictor variables are shown in Tables 7, 8, and 9. Predictor variables listed in Tables 7, 8, 9 were those with strong  $\chi^2$  and  $\alpha$  values.

As shown in Table 7, the community involvement in RSW sorting strongly correlated with the training program on 3R's activities, the availability of solid waste bank, and the existence of environment cadre (reject  $H_0$ ). The training program gave strongest correlation with the

**Table 7** Results of  $\chi^2$  correlation test between the community sorting activity and the predictor variables

Predictor variables	Degree of freedom	$\chi^2$ value	Calculated $\alpha$	Decision
Training program on 3R (X8)	1	11.108	0.001	Reject $H_0^a$
Availability of solid waste bank (X6)	1	8.408	0.004	Reject $H_0^a$
Existence of environment cadre (X10)	1	7.328	0.007	Reject $H_0^a$
Knowledge in sorting (X2)	2	1.985	0.371	Accept $H_0^b$
Economical strata (X1)	2	0.657	0.720	Accept $H_0^b$
Availability of information concerning 3R from mass media (X9)	1	0.139	0.709	Accept $H_0^a$
Knowledge in GHG (X4)	1	1.693	0.193	Accept $H_0^a$
Knowledge in effects of SW to GHG emission (X5)	2	4.451	0.108	Accept $H_0^b$

<sup>a</sup>  $\chi^2$  (1:0.10) = 2.706

<sup>b</sup>  $\chi^2$  (2:0.10) = 4.605

**Table 8** Results of  $\chi^2$  correlation test of the community composting activity and the predictor variables

Predictor variables	Degree of freedom	$\chi^2$ value	Calculated $\alpha$	Result
Availability of composting facilities (X7)	1	55.811	0.000	Reject $H_0^a$
Training program on 3R (X8)	1	13.271	0.000	Reject $H_0^a$
Knowledge in composting (X3)	2	12.656	0.002	Reject $H_0^a$
Existence of environment cadre (X10)	1	9.913	0.002	Reject $H_0^a$
Availability of information concerning 3R from mass media (X9)	1	3.854	0.050	Reject $H_0^a$
Knowledge in effects of SW to GHG emission (X5)	2	4.782	0.092	Reject $H_0^b$
Knowledge in GHG (X4)	1	0.226	0.634	Accept $H_0^a$
Availability of solid waste bank (X6)	1	0.159	0.690	Accept $H_0^b$
Economical strata (X1)	2	1.557	0.459	Accept $H_0^b$

<sup>a</sup>  $\chi^2$  (1:0.10) = 2.706

<sup>b</sup>  $\chi^2$  (2:0.10) = 4.605

**Table 9** Results of  $\chi^2$  correlation test between the treatment of RSW recyclable waste materials and the predictor variables

Predictor variables	Degree of freedom	$\chi^2$ value	Calculated $\alpha$	Result
Availability of solid waste bank (X6)	1	16.440	0.000	Reject $H_0^a$
Existence of environment cadre (X10)	1	9.514	0.002	Reject $H_0^a$
Training program on 3R (X8)	1	3.929	0.047	Reject $H_0^a$
Availability of information concerning 3R from mass media (X9)	1	1.520	0.218	Accept $H_0^a$
Economical strata (X1)	2	3.834	0.147	Accept $H_0^b$
Knowledge in effects of SW to GHG emission (X5)	2	0.987	0.611	Accept $H_0^b$
Knowledge in GHG (X4)	1	0.016	0.899	Accept $H_0^a$

<sup>a</sup>  $\chi^2$  (1:0.10) = 2.706

<sup>b</sup>  $\chi^2$  (2:0.10) = 4.605

sorting activity as it provided the community with information on the importance and the method of RSW sorting. This result met the conclusion of earlier study, which stated that routine training program could enhance solid waste separation by the generators [7]. The test results also revealed that the availability of solid waste bank gave strong correlation with community sorting activity. The solid waste bank provided access to the community to earn and save money from the recyclable waste

component value. Community activity in RSW sorting was also correlated with the existence of environment cadres, whose task was to guide the householders to do 3R's activities. In contrast, the economic strata of the community, role of mass media, knowledge on green house gases, knowledge in effects of the solid waste to GHG emission community, and knowledge in sorting of the solid waste did not correlate with RSW sorting activity (accept  $H_0$ ). This may reveal that the sorting activity has



been accepted by the community of all strata as part of their involvement in RSW management.

The local government and the NGOs provided composting facilities for the community. These facilities were “Takakura” composting baskets, composting drums, and a compost house. Results of the survey showed that 10 respondents from 17, who did composting (58.8 %), performed individual composting process; in which 8 respondents (47 %) used “Takakura” baskets and the two others (11.8 %) used composting drums. Seven respondents (41.2 %) preferred to use communal composting in the compost house.

Although the facilities were provided, only limited number of respondents involved in composting. The most probable reasons of this situation were the low selling price of compost, which was only IDR 700/kg or USD 0.05/kg, a lack of market for the compost product, and the lengthy period needed for the composting process [31, 38, 39]. Maeda reported that only about 200 out of 1000 householders practiced composting in 2009 in Surabaya City, where an NGO “Pusdakota” was located. This author also stated that composting was easy, but required extra preparation work (cutting the solid waste into small pieces), and continuous care for moisture and insect control [38].

The results of  $\chi^2$  correlation test (Table 8) showed that the composting activity by the community showed strongest correlation with the availability of the composting facilities. Other factors which gave correlations were training program, knowledge in composting, existence of environment cadres, role of mass media, and knowledge in effects of the solid waste to GHG emission. Knowledge in GHG, economic strata, and availability of solid waste bank did not correlate with composting activity (accept  $H_0$ ). The solid waste bank does not give correlation to the composting activity by the community, because it only accepts non-compostable RSW materials, such as paper, plastics and metals.

The recyclable RSW materials, which comprised waste paper, plastics, and textile were used as raw materials for handcraft product or sold to the solid waste bank and the informal sector. The correlated predictor variables to community activities in treating the recyclable non-compostable RSW materials were: availability of solid waste bank, availability of environment cadre, and training program. The mass media, economical strata, knowledge in GHG, and knowledge in effects of the solid waste to GHG emission did not correlate to the recycling activity of non-compostable solid waste (Table 9).

## Conclusion

The RSW generation rate in Tenggilis Mejoyo District was 0.29 kg/person day, producing a total 16.84 tons of RSW every day. If community participation in the 3R’s program

works optimally, the RSW could be reduced up to 67.92 %. The current data on community participation in RSW reduction in the study area were: 37 % of the respondents separated the RSW into recyclables and biodegradable waste and 17 % performed composting activity. Three main reasons of those who did RSW reduction were self awareness (41 %), instruction of community leader (30 %), and effect of training (11 %).

The community in Tenggilis Mejoyo District has not fully participated in performing the 3R’s activities of RSW, although a number of facilities (composting units, environment cadres, training program) were provided by the local authority and the NGOs. This proved that the community awareness and participation in 3R’s activities were still low. In such a situation, promotion activities should be addressed on creating better and clear responsibilities among the government agencies and NGOs. Predictor variables, which showed strong correlations with the community activities, should be considered for supporting the promotion program.

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