Journal of Sustainability Science and Management
Volume 20 Number 7, July 2025: 1452-1466
eISSN: 2672-7226

POTENTIAL FOR REDUCING, REUSING AND RECYCLING PLASTIC WASTE FROM DOMESTIC SOURCE

RUSLINDA YENNI[1], LESTARI RESTI AYU[1]*, GUNAWAN HENDRA[2] AND FAUZI MHD[3]

[1]Department of Environmental Engineering, Universitas Andalas, Pauh, 25175 Padang, West Sumatra, Indonesia. [2]Department of Civil Engineering, Universitas Andalas, Pauh, 25175 Padang, West Sumatra, Indonesia. [3]Department of Environmental Engineering, Faculty of Civil and Environmental Engineering, Institut Teknologi Bandung, 40132 Bandung, West Java, Indonesia.

**Corresponding author: restiayul@eng.unand.ac.id*
http://doi.org/10.46754/jssm.2025.07.008
Submitted: 11 May 2024 Revised: 2 December 2024 Accepted: 25 December 2024 Published: 15 July 2025

Abstract: The increase in plastic waste generation may adversely impact human health and the environment, so, it is necessary to implement waste management initiatives through the implementation of the 3R principles: Reduce, reuse, and recycle. This research aims to analyse the potential 3R initiatives for plastic waste from households in Padang, Indonesia, specifically at coordinate's 0.95556°S 100.36056°E. Data collection was carried out by measuring the generation and composition of plastic waste directly in the field, as well as identifying 3R initiatives practised in communities through a survey and interview. The generation of plastic waste from domestic sources was 40.43 g per capita per day. The waste composition was predominantly polypropylene (42.97%), with the most common usage was food packaging (42.61%). The current 3R initiatives for plastic waste at domestic sources were 25.48% and had the potential to increase to 59.56% of the total plastic waste. Recycling had the highest potential to reducing plastic waste through involvement of the informal sector and establishment of waste banks. Implementing 3R plastic waste initiatives can also reduce the amount of plastic waste dumped in landfills.

Keywords: Reduce, reuse, recycle, generation, plastic wastes.

Introduction

The plastic has become an essential material to mankind since its discovery in 1907 (Haque & Islam, 2021). From food packaging to electronic gadgets, kitchenware, automotives, and many more, it has found its way into almost all our everyday items. Taken for granted, it is often discarded after a single use because it is cheap and easy to produce. However, due to its long degradation time, this practise will eventually lead to the accumulation of plastic waste that is harmful to humans and the environment.

Therefore, poor plastic waste management will lead to pollution that causes the destruction of important resources such as land, fresh water, and even oceans (Koide *et al*., 2010; Advisors *et al*., 2019; Zhumadilova & Zhigitova, 2023). In the ocean, large quantities of free-floating plastic waste and the resulting formation of microplastics have been determined as the biggest threat to aquatic life (Karami *et al*., 2017; Kosuth *et al*., 2018). The quantity of plastic waste is expected to outnumber fish in the ocean by 2050 (Larrivee *et al*., 2018). A study on the abundance of microplastics in the sediments of Bungus Bay, Padang has quantified the material at 228.89 particles/kg of dry sediment, which is considered a significantly large quantity (Islami *et al*., 2020). This has become a major concern today as humans struggle with the management of such waste (Raharjo *et al*., 2019).

The demand for plastic in Indonesia is increasing at a rate of 200,000 tonnes per year (Surono, 2013). According to data from the Ministry of Environment and Forestry in 2023, total waste in Indonesia had reached 17 million tonnes, with plastic waste accounting for 18.8% of that total (Ministry of Environment and Forestry, 2023). Indonesia ranks second in the world as a plastic producer and its waste mostly ends up in the ocean, reaching 187.2 million tonnes (Jambeck *et al*., 2015). The increasing amount of plastic waste has become a serious problem that requires a solution.

The increase in plastic waste also occurs in Padang, the capital of West Sumatra Province in Sumatra, Indonesia. In 2009, the composition of plastic waste from domestic sources in Padang was 12.23% only (Ruslinda *et al*., 2010). In 2020, the composition increased to 18.07%. Plastic waste is the second most abundant waste from household sources (Ruslinda *et al*., 2020). Most of this waste is not sorted and disposed of with other waste at temporary storage sites (TPS) and final processing sites (TPA), or dumped into waterways.

Plastic waste is very difficult to decompose. The disposal of plastic waste in landfills will make the land infertile due to its barrier properties. Meanwhile, the burning of plastic will generate toxic emissions in the air such as carbon monoxide, chlorine, hydrochloric acid, dioxin, furans, amines, nitrides, styrene, benzene, 1, 3- butadiene, CCl4, and acetaldehyde. These substances are carcinogenic therefore, dangerous to health (Manam & Nakkella, 2021). Only a small portion of plastic waste is managed through recycling by waste banks and the informal sector.

Law No. 18 of 2008 on Waste Management in Indonesia is a legislation that aims to reduce waste and ensure its proper handling. Waste reduction can be achieved through the three principles of reduce, reuse, and recycle (3R). Reduce (R1) involves limiting the amount of waste generated. Reuse (R2) involves using the material as long as it lasts before discarding it. Recycle (R3) is the process of turning waste into other useful products. Based on Presidential Regulation of the Republic of Indonesia Number 97, 2017, the target for reducing household waste nationwide is 30% by 2025. Waste reduction efforts in Indonesia usually focus on plastic, paper, and metal (Damanhuri & Padmi, 2019).

Considering the increasing amount of plastic waste, it is necessary to study the potential of 3R initiatives in various communities in Padang. The expected outcome is to determine the quantity of generated waste, its composition (type and use) and the potential of 3R initiatives in local communities in the city, besides providing recommendations for its management to achieve the national 30% reduction target.

Materials and Methods

Data Collection

The data collection involved both primary and secondary data. Primary data included measurements of plastic waste generation and composition from domestic sources, as well as the identification of existing 3R initiatives and calculating its potential through a survey. Secondary data included those on plastic waste generation and composition in Padang obtained from previous studies. The results were used as a comparison with the current study.

The primary data collection consisted of determining sample size, surveying, and selecting sampling locations, as well as conducting the sampling, measuring plastic waste generation and composition, and identifying the potential of 3R initiatives. The determination of sample size was based on the SNI 19-3964-1994 standard on methods for sampling and measuring samples of urban waste generation and composition (Department Pekerjaan Umum, 1994). Alternatively, it could be determined based on the minimum sample size using statistical methods, such as the Slovin method, which considered the margin of error (Damanhuri & Padmi, 2019). Calculation of the minimum sample size is stated in Equation 1:

$$n = \left(\frac{\sigma^2}{\sigma_x{}^2}\right)\left(\frac{N-n}{N-1}\right) \quad (1)$$

where:

n = minimum sample size
σ = standard deviation
σ_x = sampling errors
N = population numbers

The calculation using Equation 1 resulted in a minimum size of 88 households. To prove that samples taken from the 88 households were representative of the local community, the reliability was calculated using the following equations:

(a) Sampling Ratio (SR), which is the sampled population divided by the total population of the city (Equation 2).

$$SR = \frac{P_{sp}}{P_t} \tag{2}$$

where:

SR = Sampling Ratio
P_{sp} = population sampled
P_t = total population of the city

(b) Percentage Sampling Error (PSE) is the weight or volume of waste not sampled divided by the total weight or volume of waste generated throughout the city (Equation 3).

$$PSE = \frac{Q_t - Q_{sp}}{Q_t} \tag{3}$$

where:

PSE = Percentage Sampling Error
Q_{sp} = volume of sampled waste
Q_t = total waste volume in the city

(c) Based on the sampling results, a logarithmic relationship between SR and PSE is established, resulting in Equation 4.

$$X = 0.122\, e^{(-0.781\, Y)} \tag{4}$$

where:

X = SR expressed in decimal
Y = PSE

From the calculations, a survey reliability of 92.86% was obtained, which fell within the range of data reliability levels typically ranging from 90% to 100% (Damanhuri & Padmi, 2019). The domestic samples were then categorised based on income levels: High Income (HI), Medium Income (MI), and Low Income (LI) as classified under SNI 19-3964-1994. The Central Statistics Agency of Padang defined HI households as those earning more than IDR5,000,000 a month, MI household earnings ranged from IDR2,500,000 to IDR4,999,000, and LI households earned between IDR750,000 and IDR2,499,000. The percentage of HI households in the city was 59.72%, followed by MI at 35.55%, and LI was 4.74%. The number of domestic samples for each income level was adjusted according to the percentages of HI, MI, and LI. The calculation results indicated that minimal sample sizes of 52 HI households, 30 MI households, and five LI households were required.

The sampling of plastic waste from households was represented by three districts in Padang: Koto Tangah sub-district representing the most populous area, Padang Barat sub-district representing the city centre, and Lubuk Kilangan sub-district representing the suburbs. Table 1 shows the number of households in each sampling location according to income level.

Sampling and Measurements

Once the number and locations for sampling had been determined, a field survey was conducted to identify the specific sampling points. Subsequently, plastic waste samples were collected from households at these sampling points. According to SNI 19-3964-1994 (the Indonesian National Standard for sampling waste generation and composition), the collection was carried out continuously for eight consecutive days. One day before the sampling, plastic bags were distributed to collect the plastic waste generated within the day. The waste samples

Table 1: Sampling size in sampling location

Location	Sampling Size	Income Level		
		LI	MI	HI
Koto Tangah	57	3	20	34
Lubuk Kilangan	14	1	5	8
Padang Barat	17	1	6	10
Total	**88**	**5**	**31**	**52**

LI: Low Income, MI: Medium Income, HI: High Income.

were brought to a specific location to quantity and identify the plastic composition. The plastic waste were weighed and sorted based on type and usage. Tables 2 and 3 show the groups of plastic waste types and their use.

Table 2: Plastic waste by type

No.	Plastic Waste Type
1	PETE (Polyethylene Terephthalate)
2	HDPE (High-density polyethylene)
3	PVC (Polyvinyl chloride)
4	LDPE (Low-density polyethylene)
5	PP (Polypropylene)
6	PS (Polystyrene)
7	Others/multilayer

Source: Damanhuri and Padmi (2019)

Table 3: Plastic waste based on its usage

No.	Usage of Plastic Waste
1	Food packaging
2	Drink packaging
3	Toiletries packaging
4	Cosmetic packaging
5	Home cleaning packaging
6	Lubricant packaging
7	Other packaging

Source: Chaerul *et al*. (2014)

Identification of 3R Initiatives

The identification of 3R initiatives was carried out through interviews and the completion of questionnaires at each domestic source. The questionnaires contained items about the 3R initiatives related to plastic waste carried out by the household. The questionnaire items are presented in Table 4. From the results, the 3R initiatives were identified and subsequently, the quantity of each plastic waste that had been reduced, reused, and recycled.

Table 4: Questions in the questionnaire to identify 3R activities

No.	Usage of Plastic Waste
1	Amount of plastic waste per day
2	Source of plastic waste
3	Plastic waste sorting at the source
4	Management of plastic waste that has been carried out
5	Approval of plastic waste processing activities
6	R1 activities performed at the source
7	R2 activities performed at the source
8	R3 activities performed at the source

Analysis of Plastic Waste Generation

Waste generation refers to the amount of waste produced from a source per unit of time. In this study, waste generation measurements were conducted continuously for eight consecutive days. As a result, two waste generation values were obtained for the same day, namely the first day (Q1) and the last day (Q8). From these two time points, a correction factor was calculated, which represented the ratio between the average waste generation for the same day and the waste generated on the first day. This correction factor was used to adjust the waste generation for other days. The unit of waste generation (q) was obtained by dividing the waste generation data by the number of residents in each household. The analysis of waste generation uses the following Equations 5 to 7:

$$Q_r = \frac{Q_1 + Q_8}{2} \tag{5}$$

$$fk = \frac{Q_r}{Q_1} \tag{6}$$

$$q = \frac{Q}{p} \tag{7}$$

where:

Q_r = average generation (kg/day)
Q_1 = waste generation at day-1 (kg/day)
Q_8 = waste generation at day-8 (kg/day)
fk = correction factor
Q = waste generation (kg/day)
q = generation units (kg/capita/day)
p = number of household residents

Analysis of Plastic Waste Composition

Waste composition comprised the weight of each plastic waste component divided by the total weight of plastic waste. Composition was expressed as a percentage of weight, which is described in Equation 8.

$$C = \frac{W_c}{W_t} \, x \, 100\% \tag{8}$$

where:

C = waste composition (%)
W_c = weight of plastic waste components (kg)
W_t = total weight of plastic waste (kg)

Analysis of 3R Initiatives

The analysis of existing plastic waste 3R initiatives was performed by calculating the percentage of each 3R initiative (R1, R2, and R3) at each domestic source. The percentage of 3R initiatives is the sum of R1, R2, and R3 percentages. The calculations are stated in Equations 9, 10, and 11.

$$R_{1e} = \frac{W_{R1e}}{W_t} \, x \, 100\% \tag{9}$$

$$R_{2e} = \frac{W_{R2e}}{W_t} \, x \, 100\% \tag{10}$$

$$R_{3e} = \frac{W_{R3e}}{W_t} \, x \, 100\% \tag{11}$$

where:

R_{1e} = percentage of existing plastic waste reduction (%)
R_{2e} = percentage of existing plastic waste reuse (%)
R_{3e} = percentage of existing plastic waste recycling (%)
W_{R1e} = weight of reduced plastic waste (kg)
W_{R2e} = weight of reused plastic waste (kg
W_{R3e} = weight of recycled plastic waste (kg)
W_t = total weight of plastic waste (kg)

Analysis of 3R Potential

The analysis of 3R potential for plastic waste was based on increasing the potential for R1, R2, and R3 initiatives, considering the total waste generation and composition at each domestic source. The percentage of the 3R potential is the sum of the percentages of the R1, R2, and R3 potential. They are calculated using Equations 12, 13, and 14.

$$R_{1p} = \frac{W_{R1p}}{W_t} \, x \, 100\% \tag{12}$$

$$R_{2p} = \frac{W_{R2p}}{W_t} \, x \, 100\% \tag{13}$$

$$R_{3p} = \frac{W_{R3p}}{W_t} \, x \, 100\% \tag{14}$$

where:

R_{1p} = percentage of potential plastic waste reduction (%)
R_{2p} = percentage of potential plastic waste reuse (%)
R_{3p} = percentage of potential plastic waste recycling (%)
W_{R1p} = weight of potential waste to be reduced (kg)
W_{R2p} = weight of potential waste to be reused (kg)
W_{R3p} = weight of potential waste to be recycled (kg)
W_t = total weight of plastic waste (kg)

Results and Discussion

Domestic Plastic Waste Generation

The waste generation measurements showed that the average unit for HI group was 41.51 g/capita/day. For the MI group, it was 49.99 g/capita/day and for the LI group, it was 29.78 g/capita/day. The average unit of plastic waste generation at domestic sources in Padang was 40.43 g/capita/day in terms of weight. The MI group had a larger unit of plastic waste generation compared with the HI and LI groups. This was because the MI group used more plastic materials in their daily activities such as food and beverage packaging and cleaning products. In contrast, the LI group used smaller sachet-sized plastic packaging, resulting in the least amount of waste generated. The daily fluctuations in the unit of plastic waste generation in Padang are shown in Figure 1.

The usage habits of packaged items contributed to the variation in plastic waste generation among income groups. Figure 1 indicated an increase in plastic waste at the

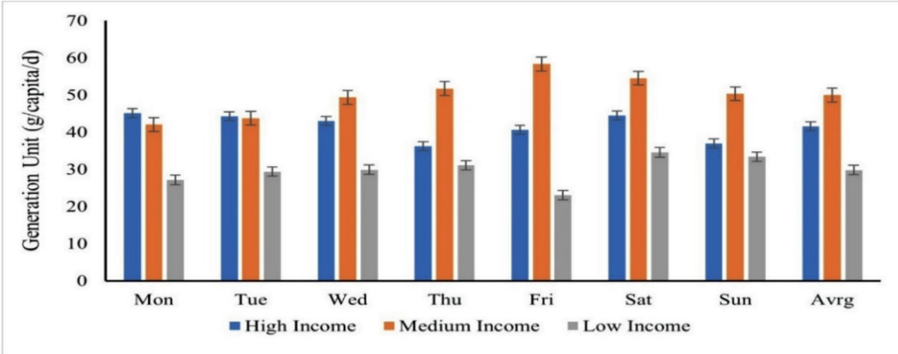

Figure 1: Daily fluctuations of household plastic waste generation by different income groups in Padang, West Sumatra, Indonesia

weekend, especially for the LI group. Based on field observations, LI households tended to use their weekends to do house chores, such as cleaning and tidying up, leading to a higher amount of plastic waste generated. In contrast, HI households spend more time engaging in activities outside the home. The t-test showed that the difference in the average plastic waste generation from these three income groups was statistically significant ($p < 0.05$).

The analysis of plastic waste generation in domestic sources revealed that MI households generated a higher amount of plastic waste compared with HI and LI households. This observation was different from previous research, which found that HI households produced more plastic waste than their MI and LI counterparts (Ruslinda *et al.*, 2010; Hafizh, 2016). Similar findings were also reported by a study in Pekanbaru, the capital of neighbouring Riau Province, where higher income levels were associated with greater plastic waste generation (Jaspi *et al.*, 2015). However, over time, it was possible that there had been a change in the trend. The largest waste generation could now be attributed to MI households, which was influenced by the changing lifestyle of each income group. Currently, households tended to spend more time outside, which affected the amount of waste generated at home. A comparison of plastic waste generation from domestic sources in Padang and Pekanbaru in different periods can be seen in Table 5.

The plastic waste generation unit mostly decreased from 2009 to 2016, but increased in 2023. The unit of plastic waste generation from domestic sources in Padang had fallen from 48.08 g to 32.67 g/capita/day from 2009 to 2016, but in 2023, it rose to 40.43 g/capita/day. This increase was influenced by the practical lifestyle choices of the population, where plastic was increasingly preferred as food and beverage packaging due to its lightweight, easy portability, and ease of cleaning. This increase could also be influenced by the surge in online shopping and food deliveries since the COVID-19 pandemic

Table 5: Comparison of plastic waste generation from domestic sources

Households	**Padang (2009) (Ruslinda, 2010)**	**Padang (2016) (Hafizh, 2016)**	**Padang (2023)**	**Pekanbaru (Jaspi, 2015)**
	Weight (g/capita/day)			
High Income (HI)	68.38	38.24	41.51	43.45
Medium Income (MI)	42.45	31.64	49.99	34.83
Low Income (LI)	33.43	28.12	29.78	35.91
Average	**48.08**	**32.67**	**40.43**	**38.06**

began in 2020. Most online purchases were packaged in plastic. A study stated that the rise in online ordering activities had led to an increase in plastic waste, especially in packaging for online products (Ruslinda *et al*., 2020). Some of this plastic contained hazardous waste like cleaning products, which accounted for 39% of the hazardous waste generated by households in Padang. As a comparison, plastic waste generation in Guayaquil, Ecuador was higher than Padang with the generation per household reported at 1.64 kg/day or 328 g/capita/day (Hidalgo-Crespo *et al*., 2021).

The percentage of plastic waste in domestic waste could be calculated by dividing the plastic waste generation by the total domestic waste generated. Table 6 shows the percentage of plastic waste in domestic waste generation. In 2009, the average percentage of plastic waste was 12.23%, which increased to 16.17% in 2016 and further increased to 19.62% in 2023. This meant that nearly one-fifth of the waste generated from domestic sources was plastic waste. This trend was consistent with the statement from the Environment and Forestry Ministry in 2023, indicating an increase in the percentage of plastic waste composition in Indonesia. In 2014, plastic waste in the country accounted for 14% (8.94 million tonnes) of total waste generated (64 million tonnes) and by 2023, it had increased to 16% (10.43 million tonnes out of 65.2 million tonnes of total waste generated).

Composition of Domestic Plastic Waste

The plastic waste in this study was categorised into seven types: Polyethylene terephthalate (PETE), high-density polyethylene (HDPE), polyvinyl chloride (PVC), low-density polyethylene (LDPE), polypropylene (PP), polystyrene (PS), and others. The average composition of plastic waste generated from domestic activities in Padang, from largest to smallest was as follows: PP plastic (42.97%), LDPE (32.36%), PETE (11.39%), HDPE (5.59%), PS (0.92%), PVC (0.02%), and others (6.75%). PP waste typically comprised fast food, snacks and seasoning packaging. LDPE waste included plastic bags, plastic and food packaging. The composition of plastic, waste based on types and income group in Padang can be seen in Table 7.

PP waste was predominantly generated by HI households while LDPE waste was generated by LI households. Several studies in other countries found the same scenario, where the dominant plastic waste found in domestic sources was PETE, LDPE, HDPE, and PP (Ferdous *et al*., 2021). HDPE, PETE, and other plastics were mostly found in MI households. HDPE waste were made up of shampoo bottles and packaging. PETE waste included beverage bottles and cups. Other wastes were shampoo and laundry detergent sachets. PVC waste was generated by HI and MI households only, which included electrical cables and insulation.

Previous research in Depok (a city in West Java Province) found that PP plastic waste was the most abundant, accounting for 49.07% of all plastic waste produced in the city (Ramandhani, 2011). Purwanigrum (2016) also found that PP waste was the most abundantly produced (30%) in the capital Jakarta (Purwaningrum, 2016). In this study, plastic waste based on types was dominated by PP plastic, accounting for 42.97%. This means that PP plastic waste dominated

Table 6: Percentage of plastic waste in domestic waste generation

Household	**Plastic Waste Percentage (%)**		
	2009 (Ruslinda, 2010)	**2016 (Hafizh, 2016)**	**2023**
High Income (HI)	13.15	16.92	17.82
Medium Income (MI)	11.17	17.01	26.07
Low Income (LI)	12.38	14.57	14.97

Table 7: Plastic waste composition

Plastic-type	Composition (%)			Average
	HI	MI	LI	
PETE	8.74	14.38	11.04	11.39
HDPE	4.81	7.57	4.39	5.59
PVC	0.04	0.03	0.00	0.02
LDPE	34.62	27.08	35.39	32.36
PP	43.95	41.81	43.13	42.97
PS	1.27	0.87	0.63	0.92
Others	6.57	8.25	5.42	6.75

the waste generated from households and was typically used for fast-food and snack packaging (Kusrini *et al*., 2019). The comparison of plastic waste composition studies in different cities and different years are stated in Table 8.

The measurement results of plastic waste composition from domestic sources in Padang, based on its usage can be seen in Table 9. The average composition of plastic waste generated

Table 8: Comparison of domestic plastic waste composition

Plastic-type	Composition (%)		
	Depok (Ramandhani, 2011)	Jakarta (Purwaningrum, 2016)	Padang (2023)
PETE	12.10	23	11.39
HDPE	10.38	11	5.59
PC	0.00	3	0.02
LDPE	27.03	1	32.36
PP	49.07	30	42.97
PS	1.16	6	0.92
Others	0.27	26	6.75
Total	**100**	**100**	**100**

Table 9: Composition of domestic plastic waste based on usage

Plastic Usage	Composition (%)			
	HI	MI	LI	Average
Food packaging	44.08	40.63	43.13	42.61
Beverage packaging	11.98	19.60	12.31	14.63
Toiletries packaging	4.37	6.82	6.08	5.76
Cosmetic packaging	0.30	0.40	0.00	0.23
House cleaning packaging	1.38	1.92	0.96	1.42
Laundry packaging	2.28	2.49	2.13	2.30
Lubricant packaging	0.09	0.47	0.00	0.19
Others	35.51	27.67	35.39	32.86

from domestic activities in Padang, from largest to smallest was as follows: Plastic used for food packaging accounts for (42.61%), others (32.86%), beverage packaging (14.63%), toiletries packaging (5.76%), laundry packaging (2.30%), home cleaning product packaging (1.42%), cosmetics packaging (0.23%,) and lubricant packaging (0.19%).

The plastic waste generated from domestic sources in households categorised as HI, MI, and LI mainly originates from its use as food packaging. HI households produced the highest amount of plastic waste from food packaging and other waste compared to MI and LI households. This occurred because HI individuals tended to consume packaged food. Plastic waste from beverage packaging, toiletries packaging, cosmetics packaging, and household cleaning products packaging were mostly generated by MI households.

When compared to research conducted in Bandung in West Java Province, there was a difference in the composition of plastic waste based on its use. In Bandung, plastic waste was observed to be primarily generated from the use of toiletries (Chaerul *et al*., 2014). Meanwhile, in this research, the composition of plastic waste in Padang was primarily from food packaging. This was influenced by the lifestyle of households, as in recent years, many had shifted to online shopping with the development of online shopping applications. Plastic waste was generated from food and beverage packaging purchased online. Additionally, the proliferation of laundry services had led households to utilise these services, resulting in a significant decrease in plastic waste from laundry packaging. Reductions have also occurred in the use of plastic waste as toiletries and household cleaning product packaging due to the prevalence of salon services and household cleaning services.

3R Potential of Domestic Plastic Waste

The 3R initiatives of domestic sources consisted of R1, R2, and R3 activities. 3R potential data was obtained by analysing the possibility of enhancing such initiatives based on the existing conditions, as well as the generation and composition of plastic waste from each household. 3R initiatives for plastic waste at domestic sources are stated in in Table 10.

The research results show that 3R initiatives had been implemented in domestic sources in Padang, except for LI households, which did not practise R1 activities. This happened because many respondents still used products in small sachets, as they were from LI households. The plastic waste generated by this group mainly consisted of food packaging, toiletries, and laundry sachets. The 3R activities implemented by domestic sources in Padang in the existing conditions accounted for 25.48% of the total plastic waste generated. HI households were more active in implementing 3R initiatives compared to MI and LI households. The initiatives by HI households in the existing conditions amount to 44.02%, MI households accounted for 21.85%, and LI households

Table 10: 3R initiatives for plastic waste at domestic sources

3R	Code	Activities
Reduce	R1.1	Avoiding the use and purchase of products that generate a large amount of waste.
	R1.2	Using products that can be refilled.
	R1.3	Reducing the use of single-use materials.
	R1.4	Providing packaging only for products that truly require it.
	R1.5	Using personal containers that can be reused when shopping.
Reuse	R2.1	Reusing containers for the same or different purposes.
	R2.2	Providing equipment for refilling common refillable products (oil, beverages).
Recycle	R3.1	Processing waste that can still be utilised to create new products.

accounted for 10.56%. Figure 2 presents the existing conditions of 3R initiatives for plastic waste in domestic sources in Padang. The difference in 3R initiatives was influenced by the awareness and desire of the community to carry them out, as well as lifestyle, income, and education level. Based on the questionnaire, it was observed that most respondents in HI households were high school graduates and undergraduates. With higher education level, the knowledge and awareness of respondents were also higher. In addition, the survey also found that almost 50% of respondents in HI households and MI households had sorted their waste at the source.

Based on Figure 2, R3 (recycling) of plastic waste was the most practiced initiative, which involved 14.64% of the total plastic waste. R3 involved selling plastic waste to third parties or buyers, who would process the waste by shredding and packing them to be resold in bulk to recycling factories. The recycling factories will then turn the plastic waste into new products or into pellets, which could be reused by other industries. Recycling industries are typically located in Java and North Sumatra Province (Stephanie, 2020). R3 was most practised among HI households (26.98%). In contrast to hazardous waste, the majority of 3R initiatives were on waste reduction. According to the findings of a study conducted at domestic sources in Padang, household hazardous waste reduction comprised 11.6% of reducing activities, 2.2% of reusing activities, and 3.6% of recycling activities (Ruslinda *et al*., 2019).

R1 (reduction) of plastic waste in domestic sources under existing conditions amounted to 5.97% of the generated waste. The R1 initiative commonly involved purchasing products in large packaging and using personal bags when shopping. HI and MI households tended to buy their daily necessities in bulk. Household products purchased were typically in large sizes, which reduced the amount of plastic packaging. Other R1 activities included the use of non-disposable items such as tumblers, flasks, and containers. Some households, especially HI and MI were accustomed to using tumblers for taking water to work or school. Another R1 initiative was reducing the use of single-use items such as using refillable products to reduce small packaging waste. These initiatives were a result of the implementation of the Padang City Mayor Regulation No. 36/2018 regarding the Control of Plastic Shopping Bag Usage (Pemerintah Kota Padang, 2018). R1 initiatives for plastic waste were more prevalent in HI households with a value of 10.70% of the total waste generated while in MI households, it was 7.21%.

R2 (reuse) initiatives involved reusing plastic packaging for same or different purposes such as mineral water bottles as containers for

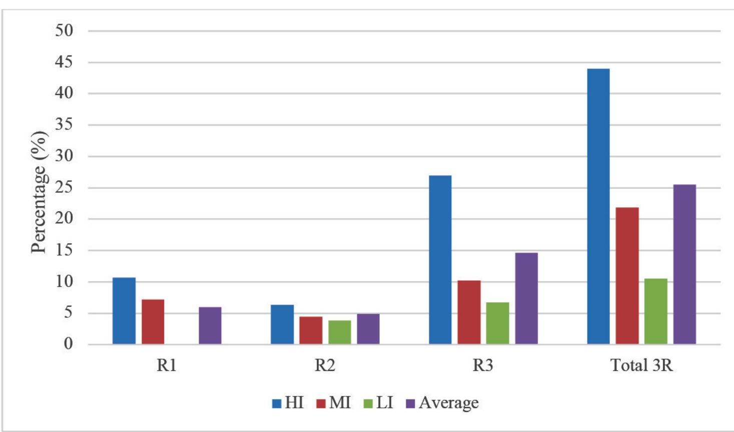

Figure 2: Existing 3R initiatives for plastic waste from domestic sources in Padang, West Sumatra, Indonesia (R1-reuse, R2-reduce, and R3-recycle)

dishwashing soap, or shampoo bottles to store refills. In existing conditions, R2 initiatives conducted by domestic sources amount to 4.87%. The reuse of plastics was also most commonly practised by HI households on 6.33% of the total plastic waste they generated, followed by MI households (4.41%), and LI households (3.85%).

Based on waste generation and composition data, as well as the 3R initiatives practised, the potential for domestic plastic waste in Padang had increased by an average of 59.56%. The potential for 3R initiatives among HI households was 80.68%, which was higher than MI households at 47.91%, and LI households at 41.81%. Figure 3 presents the potential of 3R initiatives for plastic waste from domestic sources in Padang.

3R initiatives had the most potential for enhancing 3R Initiatives, which had the most room for development. Because of the waste generation measurement results, the percentage increase in R3 initiatives was significant for MI households. Furthermore, the plastic waste generated by this group was mostly composed of food and beverage packaging purchased online and made from PP and PETE plastics, both of which had potential to be recycled.

Aside from that, plastic bottle waste could be utilised as a supporting media in wastewater treatment (Nur *et al*., 2022; Fauzi *et al*., 2023a). PET, PP, LDPE, HDPE, and PS plastic bottle waste could be utilised as a supporting medium to remove contaminants in wastewater with high efficiency (Fauzi *et al*., 2023b). This was possible as these plastic bottles may host a large number of microorganisms and remove microplastics in wastewater. Microplastics were identified as the greatest danger posed to the environment (Fauzi *et al*., 2023a). Aside from that, plastic waste could be reused as a 3D printing material (Rusdyanto *et al*., 2023) and as a substrate for the pyrolysis-hydrothermal method (Lestari *et al*., 2023). If these potentials were realised, they could reduce more waste from entering landfills.

The potential R1 initiatives that could be improved included the use of larger refillable packaging, personal containers or bags when shopping and personal containers to store food. R2 initiatives with potential for improvement included reusing containers for the same or different purposes, providing containers that could be reused such as tumblers for drinking water, jerrycans for oil storage, and old plastic bags for waste disposal.

In a study by Radityaningrum *et al*. (2017) in Surabaya (the capital of East Java Province), 3R initiatives for plastic waste accounted for 15.9% (157 kg) of the total plastic waste generated, which was 39.6% (390.3 kg). Compared to this research in Padang, 3R initiatives from domestic sources were higher

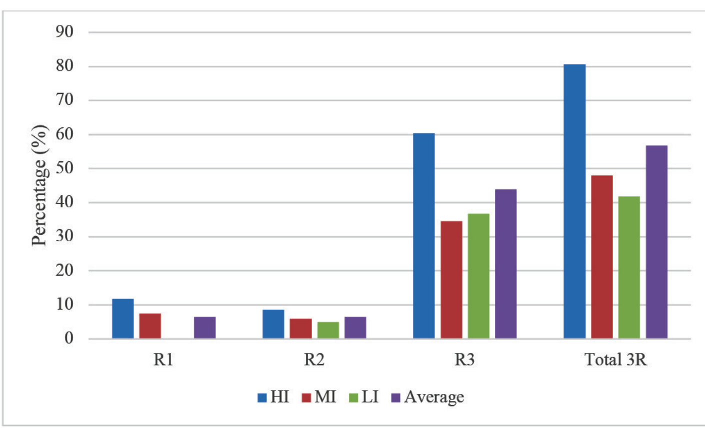

Figure 3: Potential 3R activities for plastic waste from domestic sources in Padang, West Sumatra, Indonesia

at 25.48%. This could be attributed, in part to the difference in research years. Based on the Republic of Indonesia Presidential Regulation No. 97 of 2017 on Policies and Strategies for National Household Waste and Similar Waste Management, the government aimed to reduce waste by 30% by 2025. Therefore, all Indonesian cities had to work towards achieving this target by implementing the 3R concept in their waste management. Various activities, including reducing, reusing, and recycling plastic waste were promoted through on-site programmes and social media campaigns. These 3R initiatives could help reduce waste going to landfills (Budihardjo *et al*., 2021). As a result, people would also increasingly reduce their generation of plastic waste in their daily lives.

The challenge faced in implementing plastic waste reduction at domestic sources is the need for more community participation, especially households in the LI group. The next is to address the limited facilities and infrastructure for recycling plastic waste such as the lack of waste banks. Currently, there is no plastic waste recycling industry in Sumatra. Therefore, most of the plastic waste would be sent to neighbouring Java, which would incur a high cost and long transport time. The recommendations to implement 3R initiatives from household sources include:

- Increasing community participation in reducing plastic waste in their homes through socialisation and training, becoming a customer of a waste bank and sorting of plastic waste.
- Increasing plastic waste management facilities by providing separate bins for plastic waste as well as facilitating the establishment of waste banks in each sub-district of the city.
- Establishing cooperation between the community, government, waste banks, and the informal sector, from collectors to the plastic waste recycling industry Enacting regulations or policies to reduce plastic waste in line with the 3R principles.

Conclusions

The study in Padang showed that the amount of plastic waste generated from domestic sources was 40.43 g/capita/day, which was dominated by PP (used as food packaging. The 3R initatives of plastic waste in existing conditions was 25.48%, with the most activity being recycling plastic waste through sales to the informal sector. The 3R initiatives for plastic waste had potential to be increased to 59.56% through sales activities to the informal sector and saving to waste banks, purchasing products with large packaging, using tumblers and shopping bags, and reusing plastic packaging. To implement the increase in 3R initiatives, cooperation from all parties was needed, starting from households through socialisation and training in waste recycling, waste sorting, and participation in waste banks. The government could also set up facilities and promote the recycling industry to better manage plastic waste. The data from this study could be used as initial data in planning city-scale plastic waste management, especially in Padang.

Acknowledgements

The author would like to thank the Institute for Research and Community Service, University of Andalas for funding this research under the 2023 Reputable Publication Research scheme with the Research Contract Number: T/32/UN.16.19/PT.01.03/ Energi-RPB/2023.

Conflict of Interest Statement

The authors declare that they have no conflict of interest.

References

Advisors, D., de Wit, W., Hamilton, A., Scheer, R., Stakes, T., & Allan, S. (2019). *Solving plastic pollution through accountability*. WWF—World Wide Fund for Nature, Gland, Switzerland.

Budihardjo, M. A., Yuliastuti, N., & Ramadan, B. S. (2021). Assessment of greenhouse gas emissions from integrated solid waste management in Semarang City, Central Java, Indonesia. *Evergreen*, *8*(1).

Chaerul, M., Fahruroji, A. R., & Fujiwara, T. (2014). Recycling of plastic packaging waste in Bandung City, Indonesia. *Journal of Material Cycles and Waste Management*, *16*, 509-518.

Damanhuri, E., & Padmi, T. (2019). *Pengelolaan sampah terpadu*. ITB Press.

Departemen Pekerjaan Umum. (1994). *SNI 19-364-1994 Tentang Metode Pengambilan dan Pengukuran Contoh Timbulan dan Komposisi Sampah Perkotaan*.

Fauzi, M., Soewondo, P., Darnas, Y., Handajani, M., Tedjakusuma, T., Nizar, M., Muna, C. R., & Nur, A. (2023). Microplastics abundance in domestic wastewater as a pollutant source for the Daroy River, Indonesia. *Journal of Water and Land Development*.

Fauzi, M., Soewondo, P., Nur, A., Handajani, M., Tedjakusuma, T., Oginawati, K., & Setiyawan, A. S. (2023). Performances of Polyethylene Terephthalate plastic bottles waste as supporting media in domestic wastewater treatment using aerobic fixed-film system. *Journal of Ecological Engineering*, *24*(10).

Ferdous, W., Manalo, A., Siddique, R., Mendis, P., Zhuge, Y., Wong, H. S., Lokuge, W., Aravinthan, T., & Schubel, P. (2021). Recycling of landfill wastes (tires, plastics, and glass) in construction–A review on global waste generation, performance, application, and future opportunities. *Resources*, *Conservation and Recycling*, *173*, 105745.

Hafizh, M. (2016). *Timbulan*, *Komposisi*, *Karakteristik dan Potensi Daur Ulang Sampah Domestik Kota Padang*. Tugas Akhir Sarjana Jurusan Teknik Lingkungan Universitas Andalas.

Haque, M. S., & Islam, S. (2021). Effectiveness of waste plastic bottles as construction material in Rohingya displacement camps. *Cleaner Engineering and Technology*, *3*, 100110. https://doi.org/https://doi.org/10.1016/j.clet.2021.100110

Hidalgo-Crespo, J., Amaya, J. L., Soto & Caamaño-Gordillo. L., (2021). Domestic plastic waste in the city of Guayaquil: Generation rate and classification. *The 19th LACCEI International Multi-Conference for Engineering, Education, and Technology: "Prospective and trends in technology and skills for sustainable social development"*, Buenos Aires, Argentina.

Islami, M. D., Elizal, E., & Siregar, Y. I. (2020). Distribution of microplastic at sediments in the Coast of Bungus Bay, Padang, West Sumatera Province. *Journal of Coastal and Ocean Sciences*, *1*(1), 7-15.

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

Jaspi, K., Yenie, E., & Elystia, S. (2015). Studi timbulan komposisi dan karakteristik sampah domestik Kecamatan Tampan Kota Pekanbaru. *Jurnal Online Mahasiswa Fakultas Teknik Universitas Riau*, *2*(1), 1-6.

Karami, A., Golieskardi, A., Keong Choo, C., Larat, V., Galloway, T. S., & Salamatinia, B. (2017). The presence of microplastics in commercial salts from different countries. *Scientific Reports*, *7*(1), 46173.

Kementerian Lingkungan Hidup dan Kehutanan. (2023). *Capaian Kinerja Pengelolaan Sampah*. https://Sipsn.Menlhk.Go.Id/Sipsn/

Koide, H., Seiichi, T., Tamura, K., Jung, W., Nakayama, H., & Matsuda, S. (2010). Possibility of cooperation for low carbon society: Comparison of the Fukuoka and Busan metropolitan cities. *Journal of Novel Carbon Resource Science*, *2*, 21-35.

Kosuth, M., Mason, S. A., & Wattenberg, E. V. (2018). Anthropogenic contamination of tap water, beer, and sea salt. *PLOS ONE*, *13*(4), e0194970.

Kusrini, E., Supramono, D., Muhammad, I. A., Pranata, S., Wilson, D. L., & Usman, A. (2019). Effect of polypropylene plastic waste as co-feeding for production of pyrolysis oil from palm empty fruit bunches. *Evergreen*, *6*(1).

Larrivee, R., Ergastolo, M., & Robledo, L. (2018). *Plastic pollution primer and action toolkit: End plastic pollution*. EDN.

Lestari, R., Wahyuningsih, T. D., & Kartini, I. (2023). High quantum yield Nitrogen-Carbon Dots (N-CDs) from plastic waste. *Evergreen*, *10*(3).

Manam, V. K., & Nakkella, A. K. (2022). *Plastic waste management: Turning challenges into opportunities*. New Delhi: Bharti Publications.

Nur, A., Fauzi, M., Soewondo, P., Setiyawan, A. S., & Oginawati, K. (2022). The occurrence of microplastics on the start-up process of an anoxic biofilm batch reactor. *GEOMATE Journal*, *22*(90), 63-70.

Pemerintah Kota Padang. (2018). *Peraturan Walikota Padang Provinsi Sumatera Barat No. 36 Tahun 2018 Tentang Pengendalian Penggunaan Kantong Belanja Plastik*.

Peraturan Presiden Republik Indonesia Nomor 97 Tahun 2017. (2017). *Peraturan Presiden Republik Indonesia Nomor 97 Tahun 2017 Tentang Kebijakan Strategi Nasional Pengelolaan Sampah Rumah Tangga dan Sampah Sejenis Rumah Tangga*.

Purwaningrum, P. (2016). Upaya mengurangi timbulan sampah plastik di lingkungan. *Indonesian Journal of Urban and Environmental Technology*, *8*(2), 141-147.

Radityaningrum, A. D., Caroline, J., & Restianti, D. K. (2017). Potensi reduce, reuse, recycle (3R) sampah pada bank sampah 'Bank Junk for Surabaya Clean (BJSC). *Jukung Jurnal Teknik Lingkungan*, *3*(1), 1-11.

Raharjo, S., Bachtiar, V. S., Ruslinda, Y., Matsumoto, T., & Rachman, I. (2019). Improvement of recycling-based municipal solid waste management in Padang City, West Sumatera, INDONESIA. *IOP Conference Series: Earth and Environmental Science*, *245*, 012007.

Ramandhani, T. A. (2011). Analisis timbulan dan komposisi sampah rumah tangga di Kelurahan Mekar Jaya (Depok) dihubungkan dengan tingkat pendapatan-pendidikan-pengetahuan-sikap-perilaku masyarakat. Tugas Akhir. Fakultas Teknik. Program Studi Teknik.

Rusdyanto, B., Imaduddin, F., & Ariawan, D. (2023). The tensile properties of recycled Polypropylene Filament (rPP) as 3D printing material. *Evergreen*, *10*(1).

Ruslinda, Y., Abuzar, S. A., & Aziz, R., (2010). Timbulan, komposisi, dan potensi daur ulang sampah dari berbagai sumber di Kota Padang. *Jurnal Purifikasi*, *11*(2), 95-108.

Ruslinda, Y., Aziz, R., & Putri, F. F. (2020). Analysis of household solid waste generation and composition during the COVID-19 pandemic in Padang City, Indonesia. *Indonesian Journal of Environmental Management and Sustainability*, *4*(4), 116-124.

Ruslinda, Y., Raharjo, S., Aziz, R., Dewilda Y., & Nabila, A. (2018). Investigation of Household Hazardous Waste (HHW) generation and composition in Padang City, Indonesia. *ARPN Journal of Engineering and Applied Sciences*, *13*(19), 8082-8087.

Ruslinda, Y., Raharjo, S., Dewilda, Y., & Aziz, R. (2019). Minimisation of household hazardous solid waste (HHSW) with 4R concepts (reduce, reuse, recycle, and recovery) in Padang City, Indonesia. *IOP Conference Series: Materials Science and Engineering*, *602*(1), 012055.

Stephanie, H. (2020). *Kajian pengelolaan sampah oleh Sektor Informal di Kota Padang*. Tugas Akhir. Jurusan Teknik Lingkungan Universitas Andalas.

Surono, U. B. (2013). Berbagai metode konversi sampah plastik menjadi bahan bakar minyak. *Jurnal Teknik*, *3*(1).

Undang-Undang Republik Indonesia No. 18 Tahun 2008 Tentang Pengelolaan Sampah. (2008).

Zhumadilova, A., & Zhigitova, S. (2023). Features of modern areas of solid waste disposal. *EVERGREEN Joint Journal of Novel Carbon Resource Sciences and Green Asia Strategy*, *10*(2), 640-648.