

Article

The Impact of COVID-19 on Solid Waste Generation in the Perspectives of Socioeconomic and People's Behavior: A Case Study in Serdang, Malaysia

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Abstract: Malaysia has enforced several phases of Movement Control Order (MCO) as a quarantine period since 18 March 2020 with the intended purpose of containing the coronavirus disease (COVID-19) outbreak. The quarantine has affected people's daily lives with frequent job dismissal and retrenchment due to the struggling economic conditions of particularly small and medium businesses. This study aimed to understand the impact of MCO on solid waste management in Serdang, Selangor from the aspects of socioeconomic and people's behavior. Solid waste generation data in Serdang, Selangor was collected by KDEB Waste Management through waste weighing daily throughout 2019 and 2020. The collection was conducted according to different housing areas of Serdang. The quantitative findings have recorded a decline of 9.94% in solid waste data generation subjected to COVID-19 lockdown. In conjunction with that, an online questionnaire participated by 310 respondents was conducted on understanding the effect of the lockdown on people's behavior and socioeconomic aspect with respect to solid waste management. This study revealed that June onwards (after MCO Phase 1) generated the most solid waste. Indeed, solid waste generation due to MCO according to the waste refusal behavior is the consensus in favor of Malaysia's appropriate need for stricter policies.

Keywords: solid waste generation; socioeconomic; people's behavior; movement control order; coronavirus disease

1. Introduction

Coronavirus disease (COVID-19) spread fast in most parts of Asia, including Singapore, Malaysia, South Korea, and is more sustainable in most America and Europe [1]. In the next two months, the confirmed COVID-19 cases accumulated quickly due to the fast spread of the pandemic. Malaysia recorded the earliest case of COVID-19 on 25 January 2020, which has increased significantly in March 2020 [2]. In Malaysia, such a COVID-19 explosive pandemic has called for pragmatic precautions, including intensive case diagnosis, effective monitoring, and two weeks of mandatory quarantine. The government has then implemented the Movement Control Order (MCO) to be the national policy to flatten the pandemic curve [3].

Traffic and factory pollution has been dramatically lowered, as most of the factory and trading practices during the first period of the MCO were explicitly not permitted. Thus, it was predicted that restriction orders would increase the municipal solid waste (MSW)

through household and clinical wastes due to stay-at-home frequency. MSW typically emerged in homes, companies, institutions, businesses, and cities [4]. Household is the crucial cause of MSW in Malaysia by producing 6.1 million tons per year which made up 44.5% of comprehensive solid waste data, as reported by Khazanah Research Institute (KRI) [5]. Hoarding households could, unfortunately, set back the previous efforts of single-use plastics and waste recycling [6].

The annual MSW growth rate in developed countries was expected to be 3.2–4.5 percent, and 2–3 percent in emerging countries [7]. Effective MSW management remains an important challenge in developing countries with rapidly increasing cities, expected to increase by 50%, including Malaysia [8]. Solid waste management in the urban area is essential, which hugely influences the quality of life. Malaysia went through rapid industrialization and urbanization, resulting in increased solid waste generation and its characteristically adverse environmental effects. Thus, the current waste quality, quantity, and composition must fulfill the effective MSW management practices [9].

The Malaysian government was committed to enhancing the demand of its citizens' quality of life due to the increasing waste generation [10]. The government has consistently pursued several revised plans and strategies to ensure efficient solid waste management. Malaysia has verified its agreement with UN Framework Convention on Climate Change under Agenda 21 and the Kyoto Protocol [11]. The government of Malaysia was therefore obliged to cut national emissions of carbon dioxide to 40 percent by 2020 by increasing the management of solid waste compared to 2005. The Solid Waste Management and Public Cleansing Act (Act 672) was authorized in 2007 but postponed until it was officially transposed in 2011 into seven states and 52 municipalities responsible for waste collection works of respective concessionaires [12].

Routine municipal waste collection during COVID-19 continues to be an important area for support to maintain a resilient environment [13,14]. In this research, the status of MSW was analyzed according to monthly generation in 6 zones of areas in Serdang, Malaysia. The authors were evaluating the quantification of MSW changes in Malaysia statistically before and during the MCO. The study was conducted to observe the statistical significance of solid waste generation in municipal areas in Serdang, Malaysia. It could deliver as the basis for more resilient solid waste management, particularly during possible outbreaks or disasters. In parallel, the study also aims to link MSW generation to the perspectives of income generation and people's behavior. The study provides an evidence-based consensus on further policy development for sustainable waste management in Malaysia.

2. Methods

The study utilizes quantitative analysis principles to collect data by purposive sampling with the population trained prior knowledge. The waste weighing approach was used to gather data on solid waste generation. The data were structured using a quantitative design which includes a set of questionnaires. The quantitative assessment included the impact of socioeconomic factors and people's behavior on solid waste generation.

2.1. Study Area

Serdang (3.0220° N, 101.7055° E) is among the biggest cities in Subang Jaya, Malaysia covering 76.8 km². Serdang is located 21 km south of Kuala Lumpur. Serdang is an important business and education center point, and its population has increased substantially from 1975 to 2015, estimated to be 150,000. A significant quantity of waste has now been generated because of the increasing population.

2.2. Effect of COVID-19 Restriction on Solid Waste Generation

Serdang was divided into five zones under Subang Jaya City Council and one zone from Kajang City Council. Table 1 shows all the six zones involved under Serdang, Malaysia. In this study, KDEB Waste Management analyzed information on domestic waste collection

through much of Serdang from 1 January 2019 to 31 December 2020. In the study area, the impact on the solid waste generation of the COVID-19 restriction was evaluated. Weights are recorded every month (January 2019 till December 2020) at the weighbridge of the waste disposal and recovery center.

Table 1. Total zones involved under Serdang, Malaysia.

Area	City Council	Zones
Serdang	Subang Jaya City Council	KDSJ 20
		KDSJ 21
		KDSJ 22
		KDSJ 23
		KDSJ 24
	Kajang City Council	KDKJ 23

2.3. Effect of COVID-19 Restriction on Socioeconomic and People's Behavior

The impact of COVID-19 restriction on socioeconomic and people's behavior was assessed by surveying a sample of 310 respondents at Serdang, Malaysia. The number of respondents is small because of the lockdown conditions that prevent us from going out and collecting respondents' responses. The questionnaires were sent as Google Form via the WhatsApp and Facebook platforms. Besides, this study used the purposive sampling technique, where the participants were selected based on their knowledge about the study [15]. The questions and their objectives are shown in Table 2. The member of the household who is primarily responsible for waste management was invited to participate voluntarily.

Table 2. Questions dedicated to the citizens of the study area.

Question	Purpose and Indication
1 Are you male or female?	Information on the gender of the respondent
2 What type of ownership house are you staying in?	Information on the types of ownership of the house
3 What is your monthly household income?	To have an idea on the respect of the socioeconomic
4 How much do you spend monthly on the house?	To have an idea on the respect of the socioeconomic
5 Do you participate in waste separation?	To have an idea of the people's behavior on solid waste generation
6 Will you do waste separation if there were a bin around and if there are clear signs on it?	To have an idea of the people's behavior on solid waste generation
7 Do you believe that waste separation can improve your living environment and public health?	To have an idea of the people's behavior on solid waste generation
8 Do you think waste separation helps reduce our carbon footprints and is suitable for the environment?	To have an idea of the people's behavior on solid waste generation
9 Do you agree to live in high rise building (apartment, flat) makes it difficult to do proper waste disposal?	To have an idea of the people's behavior on solid waste generation
10 How has the pandemic affected your monthly income?	To have an overview of the solid waste quantitative aspect during lockdown
11 How many hours did you spend working from home?	To have an overview of the solid waste quantitative aspect during lockdown
12 How many times do you generate waste during the pandemic in a residential area?	To have an overview of the solid waste quantitative aspect during lockdown
13 Based on your opinion, which month duration do your family generates solid waste most?	To have an overview of the solid waste quantitative aspect during lockdown

2.4. Statistical Analysis

The reported findings were shown as a medium $\pm$ standard triplicate deviation (SD). In order to evaluate the overall production of solid waste against the collection period in Selangor, relative percentages were used as descriptive statistics. ANOVA was conducted one way to assess the MCO's municipal and district areas impact solid waste production.

Tukey's post hoc study was used in the ANOVA research. The student's *t*-test was used to equate the generation of solid waste with the local authorities. A significance level of 0.05 was carried out for the SPSS program (V.12, IBM, SPSS, New York, NY, USA) [16] for all statistical analyses [17].

3. Results and Discussion

3.1. Impact of COVID-19 Restriction on Solid Waste Generation

The correlation and discussion of the solid waste data in 2019 and 2020 has been made and compared to the pre-pandemic period which can be referred to in Table 3. The obtained results were evaluated using 95 percent confidence intervals, and the level of significance was set as $p \leq 0.05$. According to the findings, the mean value of solid waste generation in 2019 and 2020 was calculated as 1477.92 (Standard deviation, SD = 50.962) tons and 1506.42 (SD = 78.147) tons. The total solid waste produced was based on KDEB Waste Management's monthly collection from all six zones. In March 2020, MCO was implemented. Solid waste was increased slightly by 1.00 percent at the end of March 2020 (1457.22 tons). The reason was that people were flocking into the hypermarket for food stocking, which did not somehow lead to panic buying [18]. Because the government has reaffirmed the food supply to be sufficient during the MCO [5,19], this dramatic decrease was noticed when more people began to understand the importance of household items, which has minimized total solid waste [20].

Table 3. Total solid waste generation in Serdang for the years 2019 and 2020.

Month	Solid Waste Collected (Tons)		Relative Change (%)
	Year 2019	Year 2020	
January	1448.42 *	1442.61 *	−0.403
February	1530.83	1451.50 *	−5.465
March	1573.94	1457.22	−8.010
April	1389.40 *	1312.16 *	−5.886
May	1467.10	1538.69	4.653
June	1425.09 *	1553.59	8.271
July	1497.11	1563.87	4.269
August	1482.73	1526.67	2.878
September	1431.97 *	1524.96	6.098
October	1512.18	1585.20	4.606
November	1465.22	1543.04	5.043
December	1511.04	1577.58	4.218
M ± SD	1477.92 ± 50.962	1506.42 ± 78.147	

Note: * indicates the mean difference is significant at $p \leq 0.05$. M indicates the total mean. SD indicates standard deviation.

One month after the MCO was implemented, a reduction of 9.94% was recorded to total up to 1312.16 tons of solid waste. The trends of workers strongly supported work from home, and factories were forced to shut down, restaurants were forced to close. They decreased overall commercial activities [21]. After two months of the MCO, the restriction was slightly lifted, enabling certain industries to operate, as usual, raising solid waste to 1538.69 tons before growing to 1553.59 and 1563.87 tons. This can be deduced that the solid waste levels increased as more restrictions were lifted.

The rapid change in the quantity of municipal solid waste is a significant effect of disease outbreaks, and this is evident in COVID-19 [22]. There are two key reasons for this change. First, the way of living changed due to the pandemic; second, the health demands of communities raised production and consumption rates for specific zones, which is of great concern when it comes to changing municipal solid waste composition and quantities [23].

The excessive use of face masks and disposable gloves, and other personal protective equipment (PPE) after the conditional stage of MCO (July 2020 onwards) [22] is showing a substantial growth in plastic and fiber-based municipal solid waste materials. Change in

lifestyles has also increased the number of packaging paper and plastic waste, especially due to the delivery of daily needs, such as wide-ranging use of domestic service. These changes and the increased use of homemade foods in the community have increased municipal solid waste in certain societies [24,25]. In some countries, home cooking was increased to avoid virus transmission from ready-to-eat food which raised the concerns about rising household waste [24]. During this pandemic, younger generations became more aware of food waste [26].

3.2. Survey Results

According to the findings, the mean age was 28.47 (SD = 7.935) years. Almost 63.9 percent were male, and 36.9 percent were female respondents in this study. 48.7 percent of the respondents were reported to belong to the age group of 18–25 years, while as 29.7 percent belonged to the age group of 26–35 years, 19.7 percent of the respondents belonged to the age group of 36–45 years, and 1.9 percent of the respondents were above 46 years of age.

Based on Ramachandra's [27] findings, the data analyses show that household waste generation is positively linked to average family size, monthly income, and education level and negatively linked to the average age of household size. Family size is one important factor in domestic waste generation, and the findings indicate that the family size has been related to the per capita generation of waste daily. As the size of the family increases, the production per capita of waste gradually declines like the previous report [28,29], which shows that smaller families produce more per capita waste than bigger houses.

3.2.1. Quantitative Aspect of the Solid Waste Generation

Figure 1 shows the time spent for work from home during the MCO lockdown. Based on the findings, the mean value for the work duration was 103.33 (SD = 3.462) hours. While asking for the work duration during the lockdown, most respondents answered that they work less than 9 h (42.6%) and 40.0% of respondents work more than 9 h.

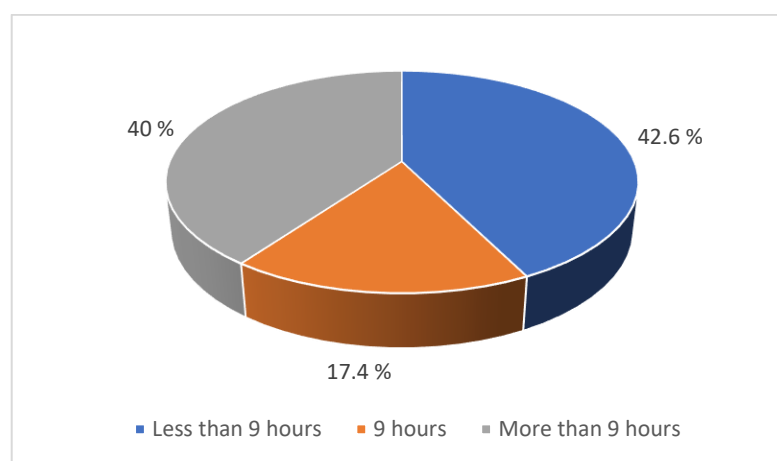


Figure 1. Duration of work during the lockdown.

Figure 2 shows the number of waste disposal during the lockdown in the residential area. Based on the survey results, the mean value of waste disposal was 77.5 (SD = 2.186). When asked about the number of waste disposal during the lockdown, around 35.2% of the respondents disposed of their waste more than three times a week. Only 19.4% of the respondents disposed of their waste once a week. The pandemic of coronavirus directly affected municipal solid waste by increasing the volume of waste, decreasing trade disruptions in agricultural and fishery exports, and indirectly increasing organic waste generation [30]. However, instead of household waste, industrial waste generation could decrease because of the pandemic disruption of industrial activity and trade in goods [24].

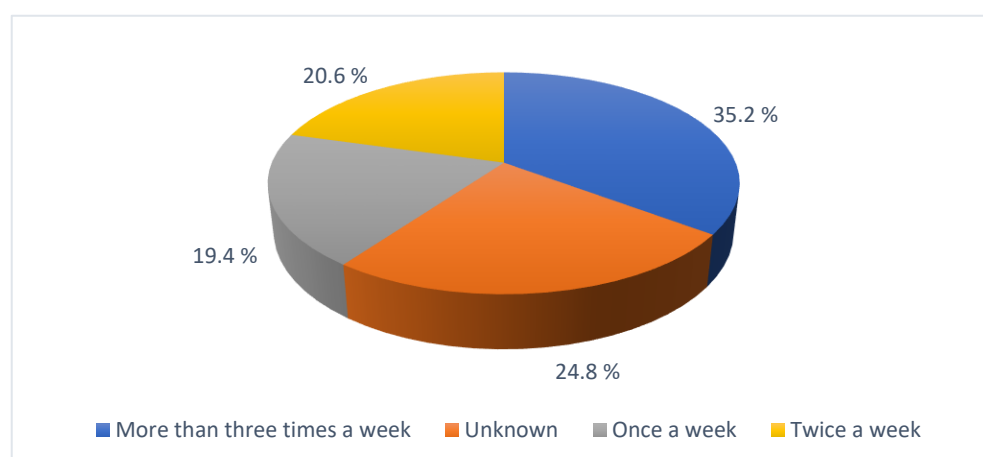


Figure 2. Frequency of waste disposal in residential areas during the pandemic.

According to the findings (Figure 3), the mean value was 77.5 (SD = 2.946). When asked about the month duration on the highest waste generation, 37.7% reported that April–June duration has the highest solid waste generation, while 25.5% for October–December month duration, 22.3% of the respondents answered in the beginning of the year (January–March) and only 14.5% of the respondents answered in the July–September month duration. Based on Table 3, the solid waste generation was high in June, July, October, and December compared to the other months due to the festival seasons, and factories and restaurants were operating as usual, resulting in an increase in waste.

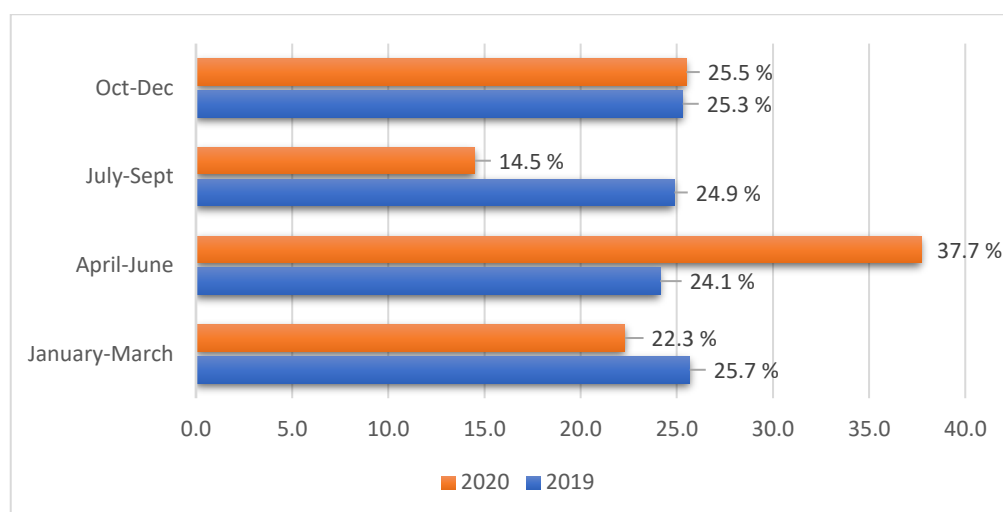


Figure 3. Solid waste generation is subjected to the duration of the month in 2019 and 2020.

3.2.2. Solid Waste Generation Subjected to Socioeconomic

Socioeconomic factor shows that COVID-19 does not affect everyone in equal measure [31]. With credibility as the primary concern, it is quite tricky to understand why infectious pandemics differ in different socioeconomic groups entirely. The family's population density and the number of tenants are important economic indicators such as education, rural, or urban areas because COVID-19 has a much more significant impact on the world's poorest regions [32].

The urban community in municipal areas often went for large shopping excursions one or two times a week for the food supplies, particularly during the MCO. They ensured food availability through food stocking that saved time from repurchasing food but could also lead to food waste because consumption is genuinely unpredictable. Over-purchasing causes most people to forget about food and not have time to eat or even cook [33]. Previous

studies also indicated that most households tended to buy more food and other unnecessary items from a less accessible source. To make matters worse, higher-income households, especially in the urban areas, will usually lead to more solid waste generation in these areas [34].

Figure 4 shows the monthly income of the household. Based on the findings, the mean value is 6439.04 (SD = 6375.538). 34.8% of the respondents reported that their income is less than RM 2500, which consider the highest percentage. In comparison, 24.2% of the respondents reported that their income was in the range of RM 5001 till RM 10,000. Only 10.7% of the respondents answered that their income was more than RM 10,000, as considered the lowest percentage. Hussain [35] declared that 72 percent of respondents reported that COVID-19 had a negative impact on their revenue and only 28 percent of respondents said no effect on their revenue. This shows the negative consequence of COVID-19 on the revenues of most of the population.

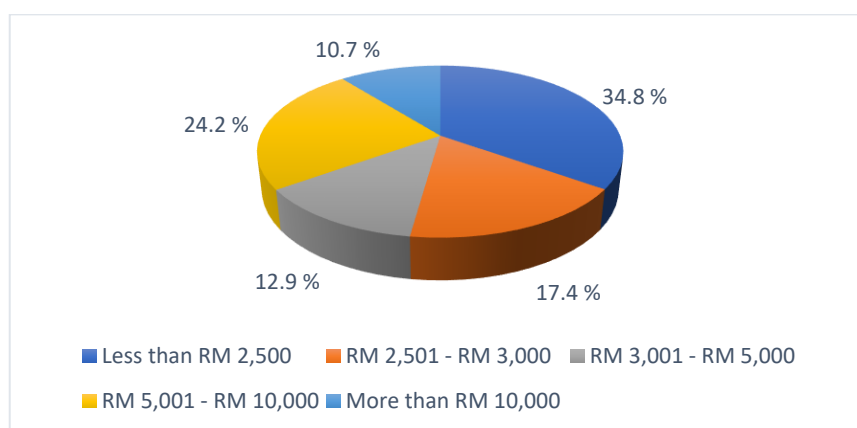


Figure 4. Household monthly income.

Figure 5 shows the amount of money spent on households every month. According to the findings, the mean value of monthly house expenses was 103.33 (SD = 2.129). When respondents were asked about the amount of money spent for households every month, 42.0% answered that they spend more than RM 1000 every month. At the same time, only 24.8% of the respondents reported that they spend less than RM 500 for households every month. Sulaiman [34] mentioned that higher households spending usually leads to more solid waste generation.

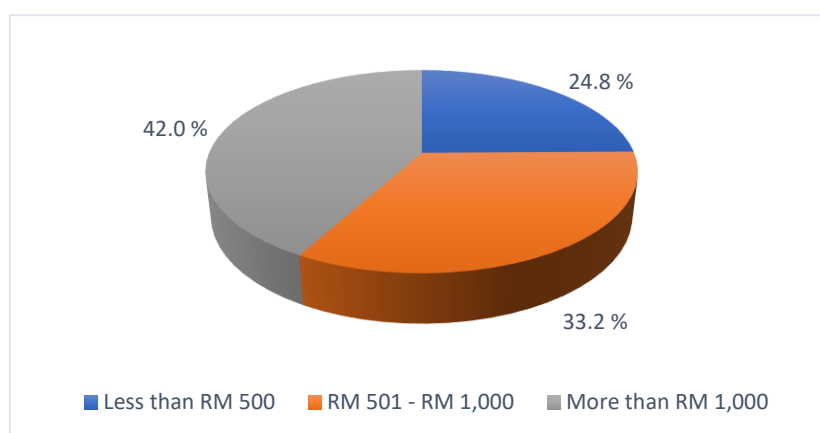


Figure 5. Monthly house expenses.

Ramachandra [27] stated that it has been found that the relationship between family income and per capita waste amounts is significant, i.e., as family income increases the pattern of consumption and purchasing trends increases, generating more solid waste,

compared to previous reports [36], which highlighted the positive link between the family income and waste generation.

3.2.3. Solid Waste Generation Subjected to People's Behavior

Based on the survey results (Figure 6), the mean value of the waste separation awareness was 62 (SD = 10.814). When asked about how waste separation can improve the living environment and public health, most people (290 out of 310 respondents) were aware of the waste separation. Only 1% of respondents (3 out of 310 respondents) reported otherwise. Sultana's [37] findings show that, out of the maximum 12 points indicating moderate awareness, the averages of participants' awareness of household solid waste management were 7.96 (SD = 0.64). It shows that most people (78.8 percent) have little to moderate awareness. However, the lowest number (15.2 percent) had a high level of sensitivity.

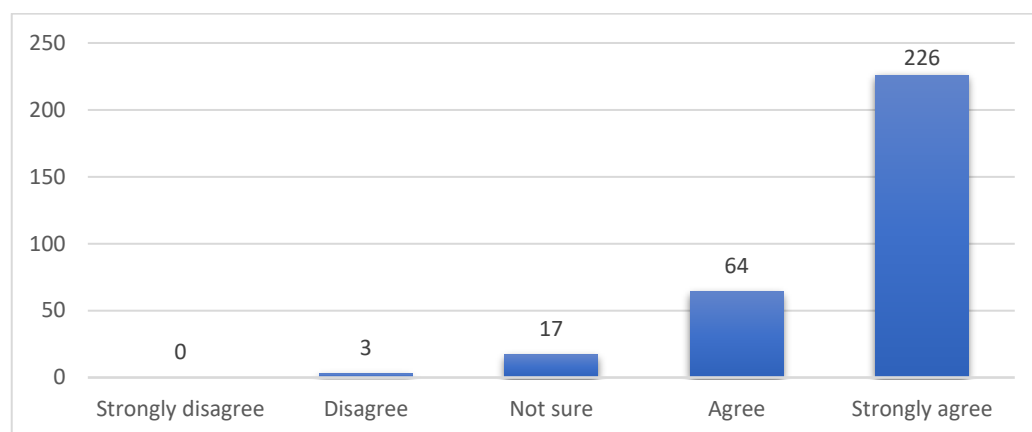


Figure 6. Awareness of waste separation can improve the living environment and public health.

According to the results, the mean value was calculated at 62 (SD = 10.278). From Figure 7, 90.3 percent of respondents said they were aware that waste separation does reduce carbon footprint, whereas 1.9 percent of the respondents said they were not aware of the reduction. This indicates a high degree of awareness about the waste separation by the population.

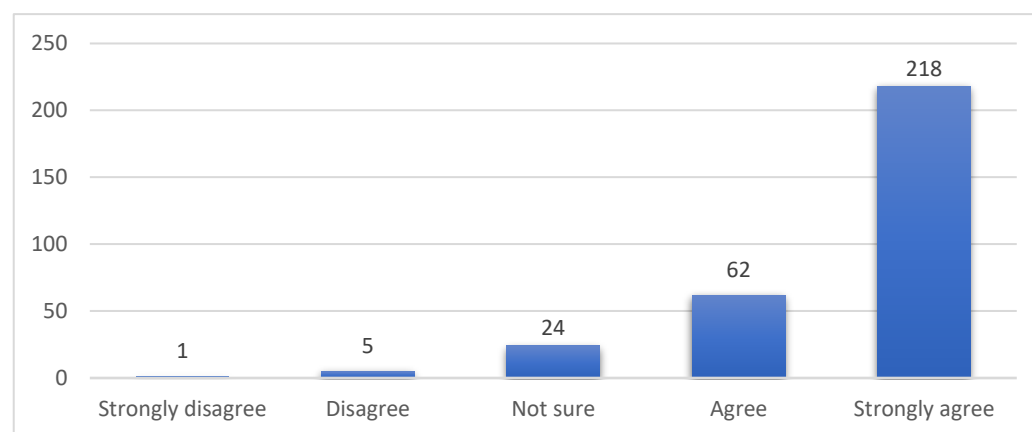


Figure 7. Awareness of waste separation helps reduce the carbon footprint.

Based on the findings, the calculated mean value was 65 (SD = 4601). From Figure 8, 63.9% of the respondents mentioned that they were aware of waste separation in high-rise buildings, whereas 12.9% of the respondents were not aware of the difficulties of waste separation in high-rise buildings. Sultana [37] declared that a median of 2.94 (SD = 1.35) of a maximum of 5 points indicates a moderate level of practical experience was found in household solid waste management. About 99 percent of people had a low to moderate practice level. Most respondents (95 percent) never used gardening for kitchen waste.

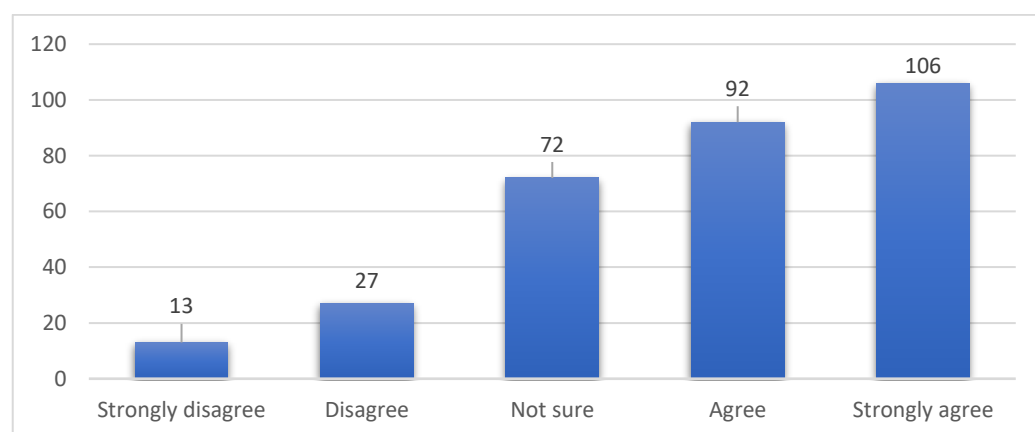


Figure 8. Awareness about living in high-rise buildings makes it difficult to do proper waste disposal.

4. Conclusions

The researchers concluded that MCO enforcement in Malaysia had a significant positive impact on solid waste reduction throughout the restriction period. Indeed, the solid waste reduction will provide evidence-based results for the government to establish stricter policies toward more efficient solid waste management in Malaysia. The study found that lockdowns of the COVID-19 pandemic significantly influence the community's consumption habits in the study area. The frequency of purchasing and shopping, such as canned food and meat, has increased, and the quality and quantitative aspect of waste has been affected by this process. The following can be described as the most crucial effects of COVID-19 on waste management: increase in domestic waste, increase in the proportion of the waste generated in the plastic industry, reduction of littered waste compared to increasing health and environmental threats of this type of waste, sharp growth in medical waste production, production of infectious waste in other places (homes that have a sick or self-quarantine person), and the low disinfection rate and the low ratio of disinfection equipment versus waste generation in the community.

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