SOLID WASTE GENERATION IN SELANGOR DURING THE COVID-19 PANDEMIC (2019-2021)

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ABSTRACT: Selangor, like many other Malaysian states, experienced various disruptions due to the pandemic. In addition to health and economic challenges, the populous state also faced notable issues regarding waste production. The COVID-19 pandemic has led to a dramatic rise in solid waste generation, especially in its two largest sources, municipal solid waste (MSW) and clinical solid waste (CSW). The pandemic resulted in people staying at home and relying on home deliveries, which led to an escalation in MSW. Healthcare workers also faced longer hours due to the growing number of COVID-19 patients, causing increased production of CSW. However, it is unclear which waste source is more affected by the pandemic. In the present study, the trend of solid waste generation in Selangor during the pandemic was investigated. A comparison was also made between the annual generation rates of both MSW and CSW, particularly spanning the period from 2019 to 2021. The findings showed that in 2019, Selangor witnessed a generation of 1,358,786 tonnes of MSW, which increased to 1,426,551 tonnes in 2020 and further escalated to 1,484,282 tonnes in 2021. As for CSW, Selangor generated a total of 7,343 tonnes in 2019, 9,703 tonnes in 2020, and 12,993 tonnes in 2021. The analysis uncovered that MSW exhibited an average annual generation rate of 4.5%, whereas CSW demonstrated a higher generation rate of 33%. An upward trend was seen in both MSW and CSW generation in Selangor from 2019 to 2021, with CSW demonstrating a significantly higher generation rate.

KEY WORDS: *COVID-19, Municipal Solid Waste, and Clinical Solid Waste.*

1. INTRODUCTION

The COVID-19 outbreak refers to the global dissemination of the respiratory disease resulting from the SARS-CoV-2 virus, as specified by the World Health Organisation (WHO) [1]. Due to its being highly contagious, the virus rapidly spreads from person to person on a worldwide scale. By March 2020, a viral pandemic was officially declared in Malaysia by Tan Sri Dato' Muhyiddin Yassin, the then Prime Minister of the country [2]. In response to the declaration, the federal government executed crucial measures to reduce the number of COVID-19 cases and exit from the pandemic [3]. Strict lockdowns were imposed during the movement control orders (MCOs), while vaccinations and boosters were administered during the national recovery plan (NRP) phase. The year 2019 passed uneventfully. However, from 2020 to 2021, Malaysian citizens found themselves needing

to adapt their lifestyles to the emerging new normal. People remained at home as food and other necessities were delivered to their doorstep, resulting in a rise in municipal solid waste (MSW). Additionally, medical personnel were obligated to work extended hours to care for the growing number of COVID-19 patients; this led to increased production of clinical solid waste (CSW). This led to a significant escalation in Malaysia's production of solid waste amid the COVID-19 pandemic. This is particularly pronounced in Selangor, the state with the highest population, as reported by the Department of Statistics Malaysia (DOSM) [4].

According to the United States Environmental Protection Agency (US EPA) [5], solid waste is any discarded items resulting from human activities. This definition covers waste sources that were most prominently generated during the COVID-19 outbreak, namely MSW and CSW. MSW comprises everyday materials produced by the public and is categorized as non-hazardous [6]. On the other hand, CSW is generated by medical centers, falling under the classification of hazardous waste due to its risks to human health and the environment [7]. Throughout the course of the pandemic, the generation of MSW and CSW increased significantly. MSW produced during this period included materials such as used face masks, food containers, and postal packages. CSW primarily comprised discarded personal protective equipment (PPE), swabs, and vaccine needles. The surge in MSW and CSW during the pandemic reflects the widespread changes in consumption patterns and the increased demand for disposables, highlighting the need for proper waste management practices to reduce their environmental impact.

MSW management in Malaysia is primarily governed by two entities, namely the Department of National Solid Waste Management (JPSPN) and the Solid Waste and Public Cleansing Management Corporation (SWCorp). Both are overseen by the Ministry of Housing and Local Government (KPKT). JPSPN functions under the Solid Waste Public Cleansing Management Act 2007 (Act No. 672), while SWCorp operates under the Solid Waste Public Cleansing Management Corporation Act 2007 (Act No. 673). However, it should be noted that only specific states implement Acts No. 672 and 673 for their MSW management practices. In the state of Selangor, the above-mentioned acts have not been adopted. Instead, Selangor adopts the Local Government Act 1976 (Act No. 171), another act under the KPKT. In accordance with this act, the Selangor state government has entrusted a company, KDEB Waste Management Sdn. Bhd. (KDEBWM) with the responsibility of handling MSW in Selangor. KDEBWM is a company that operates as a subsidiary of Menteri Besar Selangor Incorporated (MBI), with full ownership entrusted to the state government.

CSW management, on the other hand, is under the supervision of the Department of Environment (DoE), which is overseen by the Ministry of Natural Resources & Environment (NRECC). Under the Environmental Quality Act 1974 (Act No. 127), clinical waste is classified as scheduled waste with the code of SW404. Because of constraints, DoE decided to privatize CSW management services in Malaysia. As part of this approach, permits have been granted to a total of nine companies across the country. This includes Kualiti Alam Sdn. Bhd. and Radicare (M) Sdn. Bhd.; these companies offer CSW transportation and incineration services for medical centers throughout Selangor. Kualiti Alam Sdn. Bhd. has established its disposal facility in the industrial area of Ladang Tanah Merah, which is located in the district of Port Dickson, Negeri Sembilan. In contrast, Radicare (M) Sdn. Bhd. has placed its disposal facility in Telok Panglima Garang, a small town situated in the district of Kuala Langat, Selangor. Both facilities are strategically positioned to provide sufficient services to the healthcare industry in Selangor.

The widespread COVID-19 has led the Malaysian government to declare a pandemic, implementing numerous measures such as MCOs and NRP. These measures resulted in a significant increase in solid waste generation, specifically MSW and CSW. In this country, MSW management is overseen by JPSPN and SWCorp. CSW management is monitored by DoE. This study aims to investigate the trends of both MSW and CSW generation in the state of Selangor during the COVID-19 period, specifically focusing on the years 2019-2021. Since the pandemic initiated in 2020, 2019 serves as a point of reference for comparison. Additionally, the study aims to compare their annual generation rates to identify which waste source is more significantly affected by the pandemic.

2. MATERIALS AND METHODS

In this study, Microsoft Excel was utilized. Microsoft Excel, a widely used spreadsheet software, provides complete features and functions that enable efficient data calculation and visualization for research. Five key steps were involved in constructing graphs using this software: data table preparation, data selection, graph insertion, graph subtype choosing, and a final checking process [8]. The sequence of these steps is illustrated in Fig. 1.

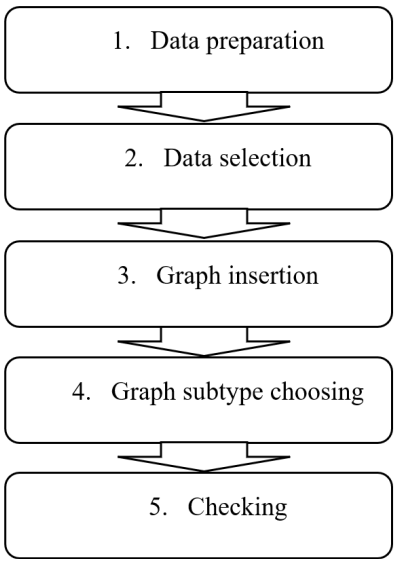

Fig. 1. Steps in generating a graph [8].

2.1. Data Preparation

The first and crucial step in this study involved preparing the data table. This step is essential in ensuring the data is well organized and structured. It involved identifying the data resources, collecting relevant data, and keying the collected data into the software.

Firstly, the specific data resources required for this study were identified. This study focused on two sources of waste: MSW and CSW. For MSW, statistical data was acquired from KDEBWM. On the other hand, CSW statistical data was collected from DoE. Once the data resources were identified, the researchers collected the data from each source. Data collection involved following formal procedures and obtaining the necessary approvals to access and use the data. The CSW data was conveniently accessible online and sourced from the DoE via the Department of Statistics Malaysia (DOSM) portal. This data was thoroughly searched and compiled over a span of one week. In comparison, the collection process for MSW data is more comprehensive. It was gathered directly from the personnel of

KDEBWM through a combination of emails and face-to-face interviews. This data collection approach was extended over two weeks, allowing for a more in-depth understanding. The collected data was then keyed in and organized in columns or rows within the Microsoft Excel spreadsheet, ensuring each data value was accurately recorded.

2.2. Data Selection

The next step involved selecting the particular data points to be included in the graph; this step is essential for visualizing the statistical figures. To accomplish this, the desired range of data was highlighted within the prepared data table.

2.3. Graph Insertion

After the data had been selected, the graph was inserted into the spreadsheet. This was accomplished by navigating to the "Insert" tab and choosing the desired graph from the variety of offered chart types. Due to the study's intention to illustrate trends over time for two sets of data in one chart, a combined graph was chosen.

2.4. Graph Subtype Choosing

The fourth step entailed choosing the appropriate subtype for the combined graph. In this case, two graph subtypes were chosen to visualize this study’s data: combined bar-line and combined line-line. Once this selection was made, the software automatically generated the graph based on the highlighted data.

The combined bar-line graph aims to demonstrate the quantity of waste generated and its generation rates in Selangor from 2019 until 2021 to investigate the state’s waste generation trends during the COVID-19 pandemic. On the other hand, the combined line-line graph compares the generation rates between the two waste sources to determine which waste source is more significantly impacted by the pandemic.

2.5. Final Checking

In the last step, the graphs produced were thoroughly checked. This involved confirming the correct data representation, ensuring appropriate labeling, and making relevant adjustments. Once the graphs were finalized, discussions were held.

3. RESULTS AND DISCUSSION

The following sections discuss the outcomes of the study's objectives. Sections 3.1 and 3.2 comprehensively investigated the trends in MSW and CSW production in Selangor amid the COVID-19 pandemic. Following a thorough analysis of these trends, Section 3.3 then highlights the waste source that is more notably impacted by the pandemic.

3.1. Municipal Solid Waste (MSW)

The MSW generation within Selangor will be discussed from 2019 to 2021. Sourced from KDEBWM, the MSW data includes waste handled by all local authorities throughout the state, such as Sabak Bernam District Council (MDSB), Hulu Selangor Municipal Council (MPHS), Kuala Selangor Municipal Council (MPKS), Selayang Municipal Council (MPS), Klang Municipal Council (MPK), Petaling Jaya City Council (MBPJ), Subang Jaya City Council (MBSJ), Ampang Jaya Municipal Council (MPAJ), Kajang Municipal Council (MPKj), Kuala Langat Municipal Council (MPKL) and Sepang Municipal Council (MPSp)

[9]. Shah Alam City Council (MBSA) is not included as it was not handled by KDEBWM at that time. Fig. 2 illustrates the quantity of MSW generated and its corresponding percentage increase or generation rate.

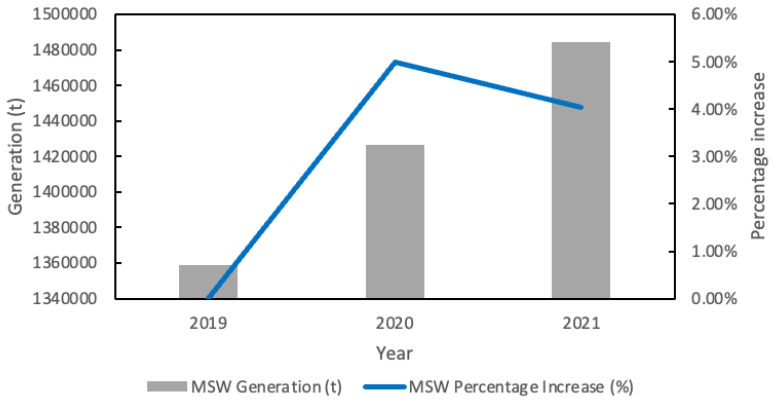

Fig. 2. MSW tonnage generation from 2019 until 2021 [9].

KDEBWM [9] data reveals that Selangor produced 1,358,786 tonnes of MSW in 2019. Notably, during this year, Malaysians could freely dine out and shop at local stores with minimal restrictions. Waste production in Selangor in 2019 was comparatively small, especially packaging from home deliveries and disposable wrappers.

By the year 2020, the MSW production in Selangor reached 1,426,551 tonnes, signifying a small growth of 5% from the preceding year, 2019. This escalation in MSW generation was largely attributed to the unique circumstances incited by the COVID-19 pandemic. As Malaysians remained cautious, the extensive use and disposal of single-use items such as face masks, food containers, and plastic utensils aimed to curb the spread of COVID-19 led to a noticeable upsurge in waste production during that period.

Moving into 2021, Selangor generated 1,484,282 tonnes of MSW, a steady rise of 4% from the previous year, 2020. With the reopening of restaurants amidst the pandemic, takeout and food delivery services were regularly conducted to those remaining at home. Simultaneously, online shopping gained popularity as it became a common mode of purchase, especially with the reopening of various business types. Consequently, the disposal of packaging materials and postal parcels further contributed to the generation of MSW.

3.2. Clinical Solid Waste (CSW)

The annual CSW generation within this state is examined, covering the timeframe from 2019 to 2021. Sourced from DoE, the CSW data includes waste produced by all public and private facilities throughout Selangor in various fields, such as medicine, nursing, dentistry, veterinary, pharmacy, and research-related practices [10]. The quantity of CSW generated and its percentage increase are depicted in Fig. 3.

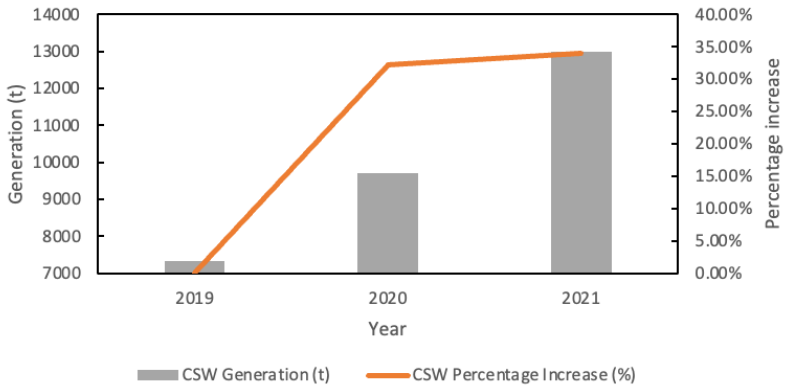

Fig. 3. CSW tonnage generation from 2019 until 2021 [10].

According to DoE [10] data, Selangor contributed 7,343 tonnes of CSW in 2019. During this particular year, the SARS-CoV-2 virus did not yet exist. The absence of this deadly pathogen resulted in a relatively low production of CSW in healthcare facilities, particularly involving used PPE, swabs, and other materials used for testing and treatment. Moreover, the low occupancy rates within hospitals prior to the pandemic contributed to the small CSW generation.

Moving to 2020, CSW generation in Selangor surged to 9,703 tonnes, reflecting a sharp increase of 32% from the previous year, 2019. This surge in CSW production happened together with the onset of the global spread of the COVID-19 virus. Throughout this year, healthcare facilities and quarantine centers experienced a surge in patient numbers, placing an overwhelming strain on the available medical personnel, including doctors, nurses, and ambulance drivers. Consequently, substantial volumes of COVID-19-related CSW were generated throughout the year.

Transitioning to 2021, Selangor's CSW output reached 12,993 tonnes, marking a 34% rise from the previous year, 2020. The introduction of various COVID-19 vaccine brands in 2021 contributed to a notable rise in the use of single-use medical instruments and materials, encompassing needles, syringes, and vaccine vials. This further heightened the CSW generation within Selangor.

3.3. Comparison Of Generation Rates

This section compares the annual percentage increases in MSW and CSW within Selangor from 2019 to 2021. To facilitate this comparison, a graphical representation is created to illustrate the generation rates of both waste sources over the three-year period, as shown in Fig. 4.

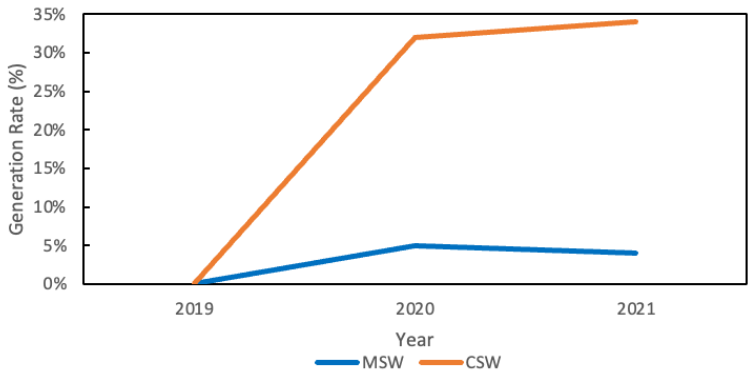

Fig. 4. Comparison of MSW and CSW annual tonnage generation rates 2019-2021.

It becomes evident that the generation rate of MSW in Selangor remained relatively low, with an average rate of about 4% from 2019 to 2021. This observation suggests that the amount of MSW generated in Selangor has not undergone significant escalation in recent years. On the other hand, the rate of CSW generation in Selangor exhibited a significantly sharper incline; its average annual growth rate was approximately 33% during the period of the COVID-19 outbreak. The heightened rate of CSW generation during the pandemic is linked to the exceptional circumstances happening at the time. Medical practitioners were disposing of clinical disposables from healthcare facilities around the clock as they attended to COVID-19-infected patients. This constant disposal of clinical waste led to a significant increase in CSW generation, surpassing the growth of MSW.

3.4. Analysis of Influential Factors by District

In the preceding sections, we analyzed the influential factors by year. We now turn our attention to exploring the factors contributing to increased waste generation across numerous districts. Utilizing data sourced from the DOSM [11], we highlighted the various determinants that shaped waste generation trends at a district level. It's important to highlight that while data on MSW generation by district is accessible, information regarding CSW generation by district remains unavailable.

The data in Fig. 5 illustrate that the Petaling district stands out for its substantial waste generation in terms of MSW. This phenomenon can be attributed to a few interconnected factors.

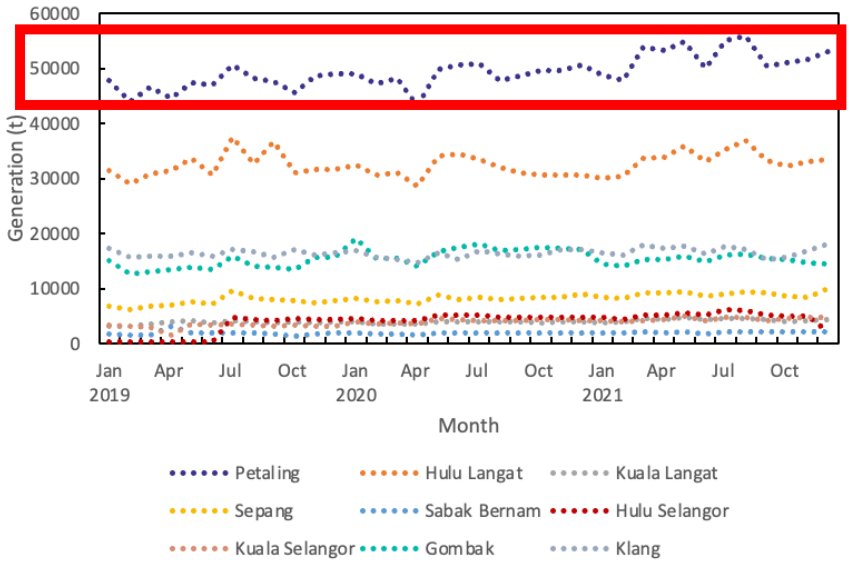

Fig. 5. MSW tonnage generation by district 2019-2021 [9].

Firstly, when we examine the demographic setting depicted in Fig. 6, Petaling emerges as the district with the highest population density within Selangor. With an astonishing population number of 2,298,130 individuals, Petaling is the sole district boasting a populace surpassing the 2 million marks. Notably, it has up to three local authorities to handle its MSW production, namely MBPJ, MBSJ, and MBSA. This correlation suggests that the amount of waste generated increases as the population number increases.

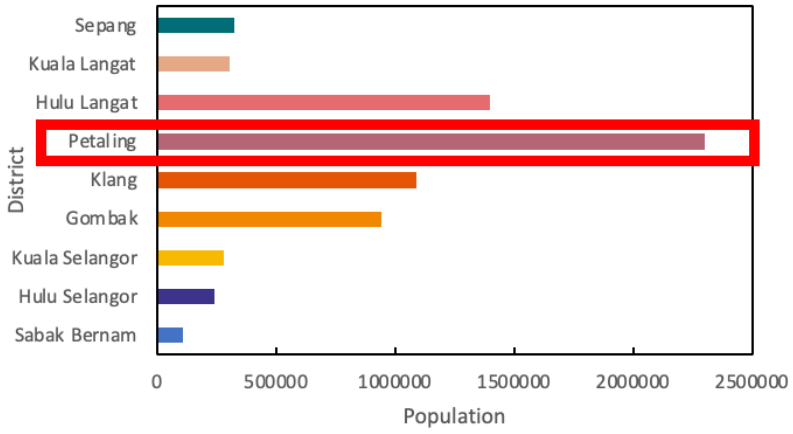

Fig. 6. Population number of each district in Selangor [11].

Fig. 7 sheds further light on Petaling's pronounced waste output by revealing the district's remarkably high household expenditure exceeding RM6,000 and income surpassing RM12,000. This economic affluence correlates with increased consumerism, as higher purchasing power leads to elevated levels of waste generation. The popular saying "the more you buy, the more you throw away" summarizes this phenomenon.

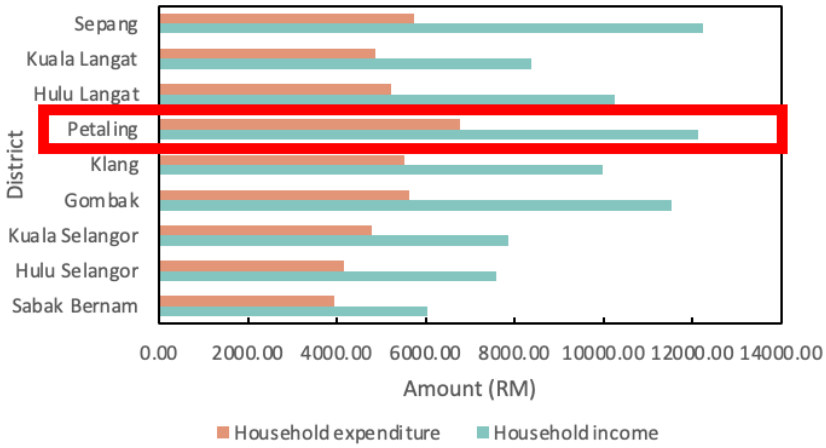

Fig. 7. Socioeconomic status of each district in Selangor [11].

Referring to Figs. 8 and 9, it's notable that Petaling has the lowest percentage of Muslims and Bumiputra among its demographics, at approximately 53%. Unlike followers of other religions, Muslims are guided by the principle of avoiding wastefulness, as emphasized in the Quranic verse:

"O children of Adam! Attend to your embellishments at every time of prayer, and eat and drink, but don't be extravagant; Surely, He does not love the extravagant people."

(Al-Araf 7:31)

The graphs prove that adherence to this teaching varies based on the percentage of Muslims within a community.

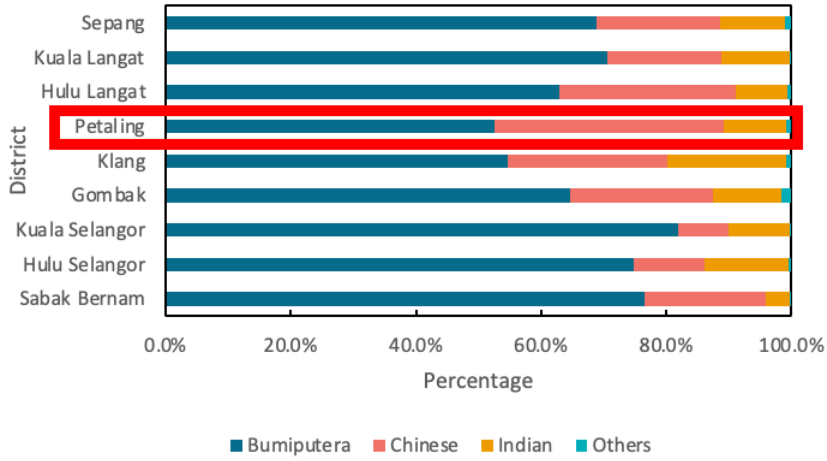

Fig. 8. Race percentage of each district in Selangor [11].

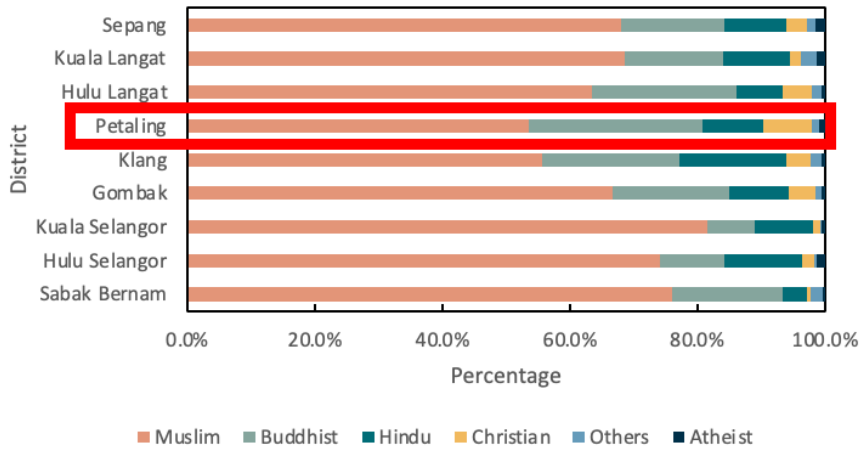

Fig. 9. Religion percentage of each district in Selangor [11].

In summary, the data presented in Figs. 5 through 9 collectively paint a comprehensive picture of Petaling's waste generation dynamics. Various factors, such as demographics and culture, explain why the district accumulates significant amounts of waste.

4. CONCLUSIONS

Amid the COVID-19 pandemic from 2019 until 2021, a noticeable surge in generation was seen in both MSW and CSW. The annual growth rate of MSW production exhibited an average of 4.5%, while CSW production experienced an annual growth rate of 33%. Compared with MSW, CSW generation clearly had a more significant impact from the pandemic. It proves that implementing effective CSW management practices is of higher importance during a global health crisis. Investing in research and innovation to explore sustainable solutions for CSW management can help reduce the environmental and public health risks associated with it.

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