

## RESEARCH ARTICLE

# Investigating the influencing factors of municipal solid waste generation in the Kuala Terengganu by correlational analysis

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## Abstract:

Municipal solid waste (MSW) management is a challenge for local authorities to ensure adequate resources is provided, but it requires a high cost in budget expenditure with the use of approximately 20% to 50% of their available municipal budget to fulfil the task. The identification of the contributing factors in generation of MSW are important to provide a picture in future planning for sustainable waste management to the authority. Therefore, this study aims to identify factors associated with MSW generation in Kuala Terengganu. In this study, data of MSW generation from 2017 to 2019 is obtained from Kuala Terengganu City Council based upon total weight of MSW collected from each administrative division and the contributory factors (population, number of residential premises and number of commercial premises) were analyzed to determine any significant relationship associates with MSW generation using IBM SPSS version 26. The result shows the mean of MSW generation and waste per capita from 2017-2019 in the District of Kuala Terengganu is 2818.53 metric tons and 0.65 kg/capita/day, respectively, and the growth rate of MSW generation was in constant of 5% in 3 years. Statistical analysis shows there is a significant strong correlation between the population and the number of commercial premises with MSW generation in Kuala Terengganu ( $p < 0.01$ ). The findings of this study can provide a baseline for the city council in arranging the resources in their further planning budget for the future to cater the need required in managing the MSW generation at each administrative division over time.

**Keywords:** commercial area, Kuala Terengganu, municipal solid waste, residential area, waste generation

## 1. INTRODUCTION

Municipal solid waste (MSW) generation is defined as the weight or volume of waste generated, and the term represents the amount of waste generated from population by a given source or category of sources (Environmental Protection Agency, 2015). The management of MSW in Malaysia is one of the essential public services under the responsibility of local authorities as stated within the Local Government Act 1976 (Government of Malaysia, 2010). Management of MSW is a challenge to local authorities as they need to ensure both adequate resources - such as manpower, suitable and specific logistic support - and a high operating cost that utilizes approximately 20% to 50% of available municipal budget (Khajuria et al., 2014). Poor management of MSW tend to cause environmental disaster such as environmental pollution, spreading of infectious disease, structural collapse, fire and explosion, landslides,

and meteorological incidents i.e. flash flood (Nor et al., 2018).

As the growth rate of MSW generation increases annually, it becomes a challenge for local authorities to ensure all wastes generated are properly collected, transported and disposed. This require an efficient waste management strategy to cope with current circumstance (Yang et al., 2018). Not only that, the MSW generation rate in Malaysia is expected to increase by 3.59% per year based on the population growth projections for the period of 2002 – 2020. In fact, total waste generated in peninsular Malaysia was 23000 tons/day in 2010 and increased to 25000 tons/day within two years. In 2020, the amount of MSW is estimated to reach 30000 tons/day and increased in parallel with population growth (Johari et al., 2014).

The generation of MSW is influenced by several factors such as societal and local community affluence, the socio-

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economic of population through the standard of living and urbanization, public habits and meteorological factors (Malaysia Ministry of Housing and Local Government, 2016). In fact, the major factors in determining the MSW are rapid urbanization, population growth and increase of socio-economic factor (Malaysia Ministry of Housing and Local Government, 2016). In general, economic growth leads to rapid urbanization and population growth in an area which ultimately contributes to greater MSW generation there. The identification of the contributing factors in the generation of MSW is important to provide a clearer planning to the authorities for sustainable waste management (Zulkipli et al., 2017).

Failure in properly identifying factors contributing to MSW generation will result in poor planning of MSW management. This will then lead to failure to achieve sustainable municipal solid waste management which tend to cause a risk of environmental pollution and waste disaster (Nor et al., 2018). At present, there are limited studies regarding municipal solid waste management generation rates and factors associated with MSW generation in Kuala Terengganu. Therefore, the objective of this study is to evaluate the generation of MSW from 2017 to 2019 and identify significant factors influencing the MSW generation thus providing reliable information for future planning of Kuala Terengganu City Council in municipal solid waste management.

## 2. METHODOLOGY

### 2.1. Characteristic of study areas

The district of Kuala Terengganu housed the capital of the State of Terengganu, and is under the jurisdiction of Kuala Terengganu City Council. Kuala Terengganu is a major hub for government quarters, commercial activities, residential and tourism industry (UPEN Terengganu, 2018). It is the most developed district in the whole state covering 21,201.5 ha and is divided into 21 administrative division as shown in the Table 1. As a capital district of Terengganu, the demographic of Kuala Terengganu has the highest population size compared to other districts with a total number of 258,600 people covering 20.7% of population in the entire state (UPEN Terengganu, 2018).

Table 1. The width area of Kuala Terengganu district administration in 2018

No.	Administrative Division	Area (m <sup>2</sup> )
1.	Atas Tol	2106000
2.	Batu Buruk	6248000
3.	Belara	67143000
4.	Bukit Besar	9066000
5.	Cabang Tiga	4512000
6.	Cenering	8741000
7.	Gelugur Kedai	4468000
8.	Gelugur Raja	2266000

9.	Kepung	4500000
10.	Kuala Ibai	5180000
11.	Kubang Parit	3464000
12.	Losong	2590000
13.	Manir	29137000
14.	Paluh	3723000
15.	Pengadang Buluh	18454000
16.	Pulau-Pulau	8571000
17.	Rengas	1942000
18.	Serada	22857000
19.	Tok Jamal	1983000
20.	Bandar Kuala Terengganu	3179000
21.	Pekan Cabang Tiga	85000
Total width area		210215000

### 2.2. Data collection

This study involves the collection of secondary data on MSW generation among all 21 administrative divisions of Kuala Terengganu. Data are obtained from the Department of Environmental Health, Kuala Terengganu City Council and Terengganu State Economic Unit. Data of MSW generation from 2017 to 2019 is obtained from Kuala Terengganu City Council based upon total weight of MSW collected from each administrative division that were sent to a landfill for disposal.

### 2.1. Statistical analysis

IBM Statistical Package for the Social Sciences (SPSS) version 26 was used to analyse the data in this study. Descriptive statistic was used to evaluate the generation of MSW from 2017 to 2019. The data were presented in tables, and expressed as mean and standard deviation (SD). To compare the average MSW generation between 2017-2018 and 2018-2019, paired sample t-test was used. Pearson correlation statistical test was applied to identify factors influencing the generation of MSW in Kuala Terengganu. *p*-value was set at 0.05.

## 3. RESULTS

Table 2 shows the distribution of MSW generation in 21 administrative divisions from 2017 to 2019. The results show that the mean of MSW generation from 2017 to 2019 is 2818.53 metric tons, with Bandar Kuala Terengganu recorded the highest MSW generation (6696.78 metric tons). Meanwhile, Pekan Chabang Tiga recorded the lowest generation of MSW (847.31 metric tons) which corresponds to its small area. The year 2019 showed the highest MSW generation in Kuala Terengganu (7141.87 metric tons) while the lowest is in 2018 with 714.87 metric tons.

Table 2. Total weight of MSW collected from each administrative division in Kuala Terengganu district

No.	Administrative Division	MSW Weight (Metric Tons)			
		2017	2018	2019	Average
1.	Atas Tol	2478.31	2583.20	2565.63	2542.38
2.	Batu Buruk	2265.42	2687.96	2844.52	2599.30
3.	Belara	2993.14	3185.35	3004.05	3060.85
4.	Bukit Besar	2773.65	2970.09	2900.86	2881.53
5.	Cabang Tiga	1742.10	1933.43	2211.36	1962.30
6.	Cenering	2889.88	3265.04	3426.70	3193.87
7.	Gelugur Kedai	1902.84	1902.84	2003.22	1936.30
8.	Gelugur Raja	894.52	985.42	1002.87	960.94
9.	Kepung	2876.30	2876.30	3254.32	3002.31
10.	Kuala Ibai	2626.54	2716.81	2845.74	2729.70
11.	Kubang Parit	2501.45	2578.36	2631.43	2570.41
12.	Losong	3652.14	3873.87	3744.24	3756.75
13.	Manir	4897.19	4637.13	4795.94	4776.75
14.	Paluh	2587.46	2762.76	2887.65	2745.96
15.	Pengadang				
	Buluh	3523.86	3523.86	3752.79	3600.17
16.	Pulau-Pulau	2010.18	1970.29	2145.88	2042.12
17.	Rengas	2110.87	2294.91	2662.26	2356.01
18.	Serada	2223.70	2394.31	2599.54	2405.85
19.	Tok Jamal	2397.65	2588.36	2578.36	2521.46
20.	Bandar Kuala Terengganu	5974.24	6974.24	7141.87	6696.78
21.	Pekan Cabang Tiga	874.22	799.21	868.50	847.31
	Total weight	56,195.66	59,503.74	61,867.73	59,189.04
	Mean±SD weight	2675.98±1158.94	2833.51±1284.02	2946.08±1292.49	2818.53±1231.45

SD = Standard Deviation

The average waste per capita produced in each administrative division is 0.65 kg/capita/day as shown in Figure 1. The administrative division of Manir recorded the maximum waste per capita generated at the study location in 2017 at 1.05 kg/capita/day while the minimum waste per capita generated is from administrative division of Cabang Tiga in 2017 at 0.27 kg/capita/day.

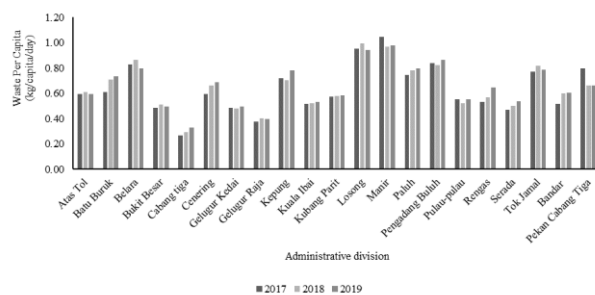


Figure 1. Distribution of waste per capita (kg/capita/day) in each administrative division at Kuala Terengganu district from 2017 to 2019

The average growth rate of MSW generation was in constant of 5% in 3 years as shows in Table 3.

Table 3. Growth rate of MSW at Kuala Terengganu district

Year	Average growth rate of MSW (%)
2017 to 2018	5
2018 to 2019	5

Statistical analysis shows that the number of population and commercial premises has a strong correlation with the generation of MSW ( $p < 0.01$ ) as summarized in Table 4. However, the number of residential premises does not influence the generation of MSW in Kuala Terengganu district ( $p > 0.01$ ).

Table 4. Correlation analysis between MSW generation with number of populations, commercial and residential premises

Variable	Pearson correlation	p-value
1. MSW generation and population	0.769**	<0.001
2. MSW generation from commercial premises and number of commercial premises	0.956**	<0.001
3. MSW generation from residential premises and number of residential premises	0.147	0.525

\*\* Correlation is significant at the 0.01 level (2-tailed).

#### 4. DISCUSSION

Result shows the average waste per capita of Kuala Terengganu district is below the average waste per capita of the state of Terengganu, which is 1.24 kg/capita/day (Kamaruddin et al., 2017). However, the increasing rate of MSW generation should be taken into consideration as the number signifies growth over time with an average of 5% increase rate. In fact, the maximum increase rate reported in a single administrative division can go as high as 13%. The result of MSW generation rate is alarming as the MSW generation rate in Kuala Terengganu is higher than the expected MSW generation increase of 3.59% per year based on the population growth and the greatest number of commercial premises projections for the period of 2002 – 2020. The maximum and minimum MSW generation, waste per capita and MSW growth rate are also different among administrative divisions in the district. These differences provide a challenge to the Kuala Terengganu City Council (KTCC), the agency who are responsible in managing MSW in the district. Not only that, KTCC is also required to provide adequate resources and MSW collection services at each administrative division. However, the result of the study can provide a baseline for the city council in arranging the resources in their further planning budget to cater for future growth of WSM generation.

Apart from that, the correlation analysis shows that the population density was one of the predictors ( $p < 0.01$ ) of MSW generation in Kuala Terengganu. Population shows a strong significant relationship to MSW generation making it quite a challenge as the Kuala Terengganu is the capital district of Terengganu and the migration of people from rural to urban area is unavoidable due to economic purpose. The administrative division of Bandar Kuala Terengganu is also popular with tourism and previous study indicates that tourism activity is also one of factors contributing to MSW generation (Afthanorhan et al., 2017). In fact, high population, coupled with local economic activities is a clear indicator why the administrative division of Bandar Kuala Terengganu experienced the highest MSW generation between 2017 and 2019.

Land use activity is another essential factor contributing to MSW generation (Chithra et al., 2016). MSW generation in the District of Kuala Terengganu has a significant relationship to commercial premises rather than residential premises. The relationship concurs with previous study that shows commercial premises contribute significantly to MSW generation similar with other cities in Asia (Chithra et al., 2016). With rapid urbanization and more residential premises built to cater the population growth, the MSW generation in District of Kuala Terengganu are expected to grow similar with other cities in Asia.

In 2016, the Malaysian government have initiated the Solid Waste Management Policy 2016 and its main objectives are to create Integrated Solid Waste Management and for the reduction of solid waste generation through waste management hierarchy (Government of Malaysia, 2016). The implementation of this policy by the government and local authorities requires cooperation of communities. As the District of Kuala Terengganu experience significant increase of MSW generation over time, the authority should take measurable steps to ensure the MSW generation could be decreased to increase the lifespan of landfills and to prevent environmental pollution due to illegal dumping of MSW. Implementation of 4R (Recovery, Reuse, Reduce and Recycle) campaign should also be emphasized within residential areas and the establishment of recovery center within the district should be promoted through private enterprise cooperation. Proper allocation of resources must also be emphasized in areas that experience high waste per capita based on the data provided. Since the growth of population and rapid land development are unavoidable due to economic reasons, Kuala Terengganu City Council as a responsible party in MSW management, should take serious action. Severe impacts to environment can be expected if the MSW generation growth rate continues without any active intervention.

#### 4. CONCLUSION

The generation of MSW in Kuala Terengganu district shows a significant increase from 2017 to 2019, despite a flat growth rate. The number of population and commercial premises are significant factors that contribute to the generation of MSW in this district. It is suggested that the authority should initiated plan to cater the growth of MSW generation annually by emphasizing on population and commercial area which is a significant contributory factor to MSW generation. Preventing failure of MSW management is essential for the protection of environmental disasters in the future.

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