

Variables Influencing Food Wastage and Rapid Composting Techniques of Food Waste in Malaysia

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Abstract-Rapid generation of food waste has become a major concern in municipal solid waste management (MSW) in Malaysia that are practically poor and unstructured. Food waste has significant adverse effects on food security, the environment and the economy, making it a significant problem that needs critical response. The current method in disposing of the waste in a landfill negatively impact human being and environmental safety. Food waste is a material produced when food is purchased, prepared and consumed. Based on the previous studies, it was found that there were variables that influence the number of food waste produced from each individual. Meanwhile, the current treatments used to treat food waste is time-consuming and unable to cope with the amount of incoming waste generated daily. Therefore, this study intended to identify the factors that influence the generation of food waste in Malaysia with the aim of analysing methods to reduce the amount of current or future food waste produced by rapid reduction techniques of composting.

Keywords:-Waste, Drivers, Waste management, Rapid composting.

I. INTRODUCTION

As a developing country with high population growth, Malaysia faced a great problem to tackle with municipal solid waste (MSW) management due to the limited budget and space to dispose of waste [1]. Budhiarta et al., (2012), discovered that food waste has dominated the overall components of MSW in Malaysia with a total of 74% compared to plastic (21%) and others (5%) [2]. Besides, a report from Jereme et al., (2016), stated that 38.23% of food waste generated from the household sector while 24.50% from wet and night markets, 23.35% from food courts/restaurants and other streams only covered 13.74% [3].

Food waste produced when food is purchased, prepared and consumed [4] from any sources including household, industrial or agricultural stream [5]. Khazanah Research Institute (2019) estimated that 16 688 tones of food waste are produced per daily in Malaysia. This scenario happened due to the several variables such as public awareness [6], eating behaviour [7], shopping behaviour [8] and policy regulations [3] that influence the huge number of food waste generated in each sector. Therefore, it is crucial to overcome the factors of food waste produced by identifying and evaluating each variable for better planning [9].

Since there are no strict policy or regulations on the management of food waste, most of the waste produced each day will end up in the landfill and triggered more

problems, especially on environment safety. Dumping of food waste in a landfill can cause serious environmental problems, such as soil pollution [10], bad odour [11] and leachate production [12]. Food waste generally degrades faster than other organic waste present in the landfill which can result in high methane production [13], [14]. Therefore, it can be concluded that dumping food waste in the landfill is not the best options and need other alternatives to manage them.

Commonly, people pay interest in recycling inorganic waste (plastic, metal and glass) compared to organic waste (food waste, newspaper and yard waste). However, according to Abdullah et al., (2013), food waste is easier to be treated because it is rich in organic matter and has more than 90% biodegradability that can easily be recycled [15].

Therefore, studies have discovered methods on managing food waste by converting them into some-value added products with a small budget or mechanism that can be profitable to the country. This study intended to identify the factors that influence the generation of food waste in Malaysia and analyze composting methods to reduce the amount of current or future food waste produced by rapid reduction techniques.

II. FACTORS INFLUENCING FOOD WASTAGE

Generally, food waste originates from each level of food supply chain comprises of the agricultural sector,

industrial production and manufacturing, markets and also from the household stream [16]. Waste is likely to occur at each stage of the process. Food waste produced when food is purchased, prepared and consumed. The rising rate of waste generation in Malaysia happened mainly due to the unmanageable demand from the population growth and their expenditure behaviours with high living standards [1].

This unmanageable demand from the population growth was further supported by Table I that shows the increase rate of waste generated in Malaysia was in line with the rise of population growth from 2005 to 2018. Numerous studies also have listed out factors contributing to food waste in the landfill [16] [18]. As shown in Fig. 1, some of the other main factors that contribute to the generation of food waste in Malaysia are public awareness [6], eating behavior [7], shopping behavior [8] and policy regulations [3].

Table 1. Waste generation in Malaysia.

Year	Population	Waste Generated
2005	25.69 million	19100 tons/day
2010	28.21 million	21596 tons/day
2018	32.50 million	38142 tons/day

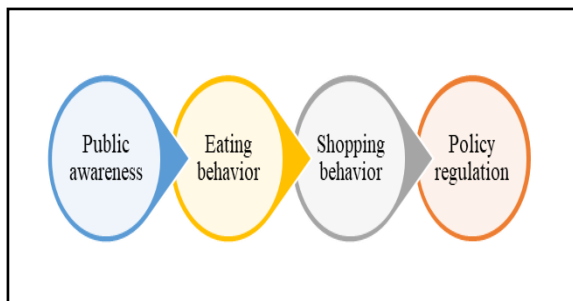


Fig 1. Drivers of Food Waste Produced.

1. Public Awareness:

Malaysia's level on the Global Food Security Index is always at an adequate standard (14th/113th). But, the problem of food wastage among its people has become a significant problem for the government to solve [6] [16]. The availability to access food in Malaysia has indirectly reduced the value of food and put the public at ease. By looking at the overloaded landfill, it can be related that environmental awareness among the public in Malaysia is still not readily adaptable. A person with no environmental consciousness does not aware that food wastage from home or restaurants leads to the piling of putrescible waste in the landfill [19] [20].

The lack of awareness comprises many aspects such as how much people realize the amount of food they have to

discard off, the knowledge to store their food, shopping planning and eating behaviour. A study by Abd Razak et al., (2018), have proved that there was a correlation between public knowledge and their involvement to the production of food waste ($\beta = .330$, $t = 3.538$, $p = .000$) [21]. From the study, it indicated that the public with low awareness prefers to neglect their responsibilities in managing the food waste. Similar with the other study, those with lack of awareness was categorized as being one of the variables that affect the perception of the consumer on the food waste issue [22].

People normally act in parallel with their knowledge in term of food waste management. Public knowledge can deduce person attitude in managing their food waste [23] [25]. The awareness of the public is an important element of the success to control the waste generation. it would only be possible to reduce the amount of food waste in the landfills if more awareness is exposed to the public and it would help to improve their habits. It is expected that as more knowledge of a person has about the consequences of food waste, the more positive impact on environmental awareness [18].

2. Eating Behaviour:

Malaysian has the behaviour to eat more than regular conventional breakfast, lunch and dinner. Jereme et al., (2017), found that some people eat roughly four to five meals a day [26]. Past study proved that Malaysia has higher consumption of food capital per day than other neighbourhood countries like Singapore and Thailand [3] since many restaurants in Malaysia are operating for 24 hours [27]. Other than that, habits to prepared excessive amounts of food at home, directly and indirectly, impact the amount of food waste. As shown in Fig. 2, this attitude has become a norm in all states in Malaysia and it becomes one of the trends that contribute to more generation of food waste in the landfill [28].

Based on the survey conducted in 2016, young generation tends to throw away at least 2 plates of meal per week. This situation occurred because people do not realize the value of the food until the recent pandemic of COVID-19 faced by the whole world and lead to a reduction in food waste. This has been recorded in the latest study where the number of food waste dropped 14.76% equivalent to 11871.70tons/ week in Malaysia [29]. Variables like working outside [30], career women [31], and food choices in Malaysia [26] have influenced the trend of eating out among urbanites [27] could be the reasons of the reduction of food waste during the pandemic in data reported by Ismail et al., (2020), since many commercial activities have temporary shutdown.

Besides, 'picky-eater' behaviour from the consumers also contributes to the high volume of food waste such as vegetables or others. Fussy or picky-eater behaviour normally comes from younger generations where they take

times before they ready to consume it. Avoiding to overcome this behaviour will be wasteful since the food ends being thrown away. On another note, Koivupuro et al., (2012), found that women tend to throw more food than man [7]. The main reason behind this predicament is that women are worried about the calories intake on the food served from the restaurant or at home compared to men. However, this statement is contradicted with few studies where women tend to feel guilty to throw away foods when they preparing the meals themselves [32] [33]. Normally, women would recycle leftover food into a new meal or properly planning their cooking. Therefore, it is quite difficult to label gender as a factor that influence the generation of food waste in terms of eating behaviour. In fact, there is no significant value found between the impact of gender on the food wastage [34].

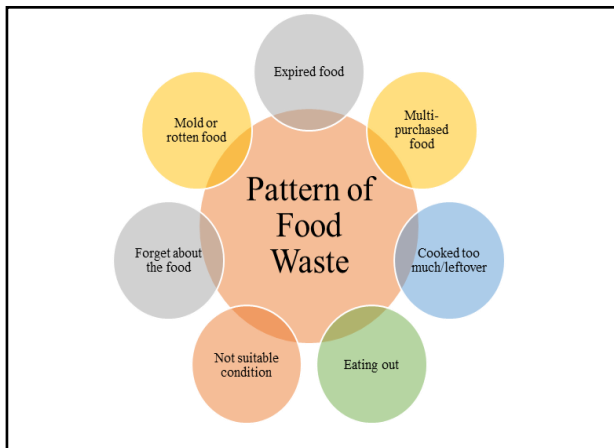


Fig 2. Pattern of Food Waste.

3. Shopping Behaviour:

As mentioned in the previous paragraph, food waste is also produced when food is purchased. Many studies have found the relationship of shopping behaviour with the production of food wastage [7] [8] [35]. This happened because people tend to buy more than necessary. Improper planning before shopping groceries leads to an increase amount of waste produced. Past study proved that, 63% of respondents from consumer believed that changes in food-related practices such as shopping planning would contribute to the reduction of food waste [36]. This is because, people with no proper planning will always be tempted to the slogan of 'buy one free one' on the sales promotion at markets [3] which this had led to more wastage when they unable to consume the products before the expiration date.

Supported by Fegalo & Ismail (2018), that study stated that huge amount grocery with the incorrect food storage could lead to rapid food spoilage or left to expired [28]. In addition, high rate of food waste produced also happened when people are not particular with the information on the product labelling such as 'best before', 'use by' and also expiration date [37]. This cause the food to be throw away because it was inedible to consume at the time.

In Malaysia, there is no act or policy that specifically discussed the wastage of food waste which the current act was limit to the management of waste in general for supermarkets or individual. Unlike France, it was the first country to take action for any supermarkets that throw away unsold food and compel them to donate the food as a charity [38]. The strict policy reinforced people to obey the new norm and to be more responsible for the food waste produced from their purchase. A recent study proved that the public will change their behaviour in following the policy making by the government ($R=0.869$) to give a positive impact on environmental protection [17].

III. RAPID COMPOSTING TECHNIQUES

Currently, methods used to treat food waste in Malaysia are animal feeding[39], composting[40], anaerobic digestion[16], incineration[41] and landfills[42]. Even though there are lists of methods that can be used to treat all kinds of food waste, but most of them has gave more draw backs than benefits. Some of them have disadvantages in term of the high risk of exogenous contamination during application [39], operational expenses, technological, economic and social challenges [13]. It is a wise choice for the food waste treatment to consider at every aspect including the process and application of the end products to the environment.

Composting is a simple low-cost treatment that degrades organic waste naturally by the help of microorganisms and transforms them into compost [43]. Composting is more favourable in many studies since it does not require high technology or cost to conduct the process. However, conventional composting took almost 4 to 5 months [44] to pass through four stages of composting which are a mesophilic, thermophilic, cooling and maturing phase. Based on data in Table 1, conventional composting could not able to cope with the large amount of food waste generated daily. Therefore, several studies have suggested multiple methods with shortest rate of composting while maintaining the compost quality based on the required standard [45] [47].

According to Geethamani et al., (2020), rapid composting is a process that primarily implements for degradation of food waste in a sustainable manner that took within a short period time [47], unlike the general composting techniques. Some of rapid composting methods proposed by previous studies for food waste are Berkeley composting [48], Takakura composting [49] and in-vessel composting [50]

1. Berkeley Composting Method:

Berkeley Composting Method (BCM) is a rapid hot composting technique developed by Robert D. Raabe and originate from Northern California, United States. BCM involves accelerated aerobic decomposition by layering

green materials such as fruits and vegetables, brown materials such as dry leaves and animal manure to create accessible finished compost in between two to three weeks (Fig. 3). Brown materials are ingredients that have high carbon content while green materials that have high nitrogen contents. The layering of these ingredients produced self-heating in the pile and destroy the pathogens which make this compost safe to be used as the fertilizer. Misra et al., (2003), have categorized BCM as a hot composting method since this method reach hot temperature faster than other conventional composting techniques [44].

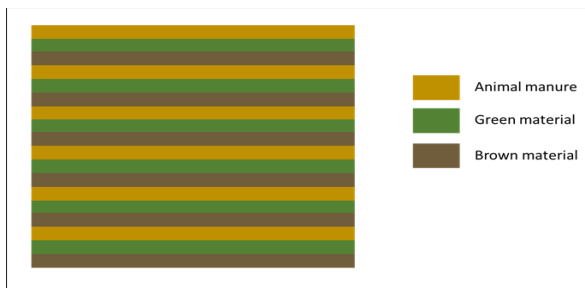


Fig3. Compost heap in Berkeley Composting Method.

Atchley (2013), revealed that there were few conditions required to achieve rapid composting using BCM especially in the early stage of composting which are compost material (mix brown and green material), C:N ratio (approximately 30:1), compost heap (1m x 1m x 1m), temperature (maintained 50°C – 60°C for 5 days) and turning times (mix thoroughly after Day 4). This method was very popular in the northern of the United States since this rapid self-heating method was favourable due to their climate but rarely found in Asian countries especially Malaysia.

The first study of BCM conducted in Malaysia was by Daud et al., (2016) which have completed the experiment in a month or less [48]. However, there were not many details provided to prove that BCM was a rapid composting method besides than the FTIR analysis for the effectiveness of compost to absorbs the light has the same performance with manufactured product. However, they have proved that BCM was a cheap technique to treat food waste [48]. Meanwhile, a recent study from Geethamani et al., (2020), revealed that layering of wet waste (fresh garbage) and dry waste (dried grass and woody materials from pruning) with the filling of cow dung was able to transform the composting materials into useable compost in 14 to 21 days [47].

Conversely, the addition of effective microbes (EM) and biochar in the composting materials in the BCM study by Nanyuli et al., (2018), able to produced matured compost in 22 days. The addition of EM and biochar has escalated the temperature up to 60°C at Day 4 and this marked as the indicator of degradation activity of microbes in the piles [52]. EM was used in the experiments to accelerate

the decomposition in the composting process [53] and biochar added for nutrient retention and improved soil structure [54]. As such, the mixture of EM and biochar with the composting materials was discovered had fastened the degradation process of food waste in BCM.

Even though the composting process in Daud et al., (2016), Geethamani et al., (2020) and Nanyuli et al., (2018), is shorter than the conventional method but based on the data provided in the studies, the standard quality of compost produced from BCM had passed several standards of compost such as TAS 9503-2005 (Thailand) and SNI 19-7030-2004 (Indonesia) [47] [48] [52].

2. Takakura Composting Method:

In 2010, Japan Institute for Global Environmental Strategies (IGES) has developed a household composting method called Takakura and was first introduced in the city of Kitakyushu, Japan. As can be seen in Fig. 4, TCM required five main materials to ensure the success of composting which were cloth to prevent insects from entering the breathable container that has been covered with cardboard, food waste and seed compost. Seed compost comprises of mixture of fermenting liquid and fermenting bed (dried leaves, rice husk, rice bran or etc.) which have been left for 3 to 5 days. The successful of seed compost is when there is build up of white mould on the surface of the seed compost [42]. This proved the effectiveness of fermenting liquid that provides an optimum condition for microbes to breed.

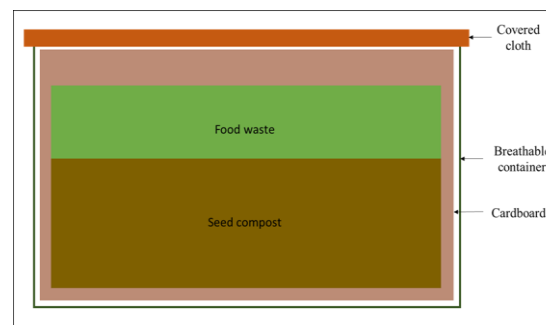


Fig 4. Components in Takakura Composting Method.

The fermenting liquid is a mixture of sugar (brown sugar and fermented foods) and salt solution (salt and fruits/vegetable waste) that are also left for 3 to 5 days. Sugar solution is considered ready when a mould layer is formed on the surface with the appearance of sweet and sour smell. TCM converts organic waste into compost by the influences of fermenting microorganisms for a shorter period of time (3 weeks or more) when compared to other conventional composting. The fastest composting was done by Dewilda et al., (2019), which had transformed the mixture of cassava peels also known as ‘Ubi Kayu’ in Malaysia, vegetable waste and fruit waste into compost in 7 days. The main reason behind the success of this rapid technique was the right amount of material which are 60%

of cassava peels and 40% of organic waste with the addition of effective microbes [55].

The ratio was considered effective since 60% of seed compost provides enough microbes together with optimum environmental conditions for them to degrade another 40% of food waste added. These effective microbes are the essential elements to enhance the rate of degradation in TCM. The findings were supported by Paola Borrero-Gonzalez et al., (2016), where they compared 5 treatments of inoculated substrate with uninoculated substrate for degradation of organic waste through TCM study. From the results, they found that inoculated substrate able to reach their maturity level in between 17 to 35 days compared to uninoculated substrate that took longer than that time [46].

In rapid composting, evaluating matured compost can be observed by parameters such as moisture content, pH or daily temperature. As mentioned before, the temperature changes act as indicator for microbial activity occurs in the reactors. The slow increase of temperature would cause longer rate of decomposition. Past studies showed that the rise of temperature in TCM normally occurred at the first and second week of composting [49] [55], but there were also found that the temperature increase after more than five weeks of composting [56] [57]. Based on the evaluation of these past studies, there are other factors that influence the composting rate which was the ratio of composting materials, frequent turning for aeration and the moisture content at the early stages of composting.

TCM has been implemented in Surabaya, Indonesia and successfully improve the municipal solid waste by 30% reduction of waste volume at the landfill within few months. Similar with BCM, though it completed in the shortest time but the quality of compost still adequate for soil application.

3. In-vessel Composting Method:

In-vessel composting or also known as enclosed composting is a method that performs the degradation of food waste inside a container or tank [10]. The large composting material was mixed inside the tank without taking up much space compared to conventional method. Fig. 5 shows the basic design of ICM which the whole container was covered with insulating materials to prevent heat loss [58]. ICM has a built-in pipe on top of the system for the airflow to ensure the emission of harmful gases or odour that can be filtered out and can be collected for further process as potential biogas [59].

The condition in the container is not influenced by the outside environment such as moisture, temperature and aeration control [10]. Thus, it helps the process of decomposition to be faster than the conventional method. It has been proved by several studies that implementation of ICM to degrade food waste can be done in less than 5

weeks depending on the balance of composting materials with the microbial activity.

Just like a good layering of animal manure, green and brown materials in BCM and effectiveness of effective microbes in TCM, the successful behind ICM is due to several factors. This included the control of moisture content in the tank, the volume of composting materials, temperature and optimum airflow. A study conducted by An et al., (2012), showed that degradation of potatoes, carrots, steamed rice, meat and leaves in a reactor can be completed in 25 days. This ICM study performed 4 kg of feedstock with optimum moisture content at the early of composting which also influence the rapid process [45].

Meanwhile, a study from Agapios et al., (2020), could only reach maturity level at 10 weeks of composting. This probably due to a high volume of green waste (75.5 ± 0.5 kg) in both containers that cause high moisture level (75.09% to 76.76%) at the early phase of composting. Therefore, it could be said that volume of green waste and moisture level play the important roles in determining the period of composting. Different from Malakahmad et al., (2017), this study emphasized that a large volume of waste is not a major challenge to reached maturity level. This was because, even though they used 12 kg of feedstock in their reactors which was much higher compared to the study by An et al., (2012) but regular rotation in the process helped for better aeration that provided the optimum environment for the microorganism to degrade materials inside the tank [60] and reach maturity stage faster than usual [60].

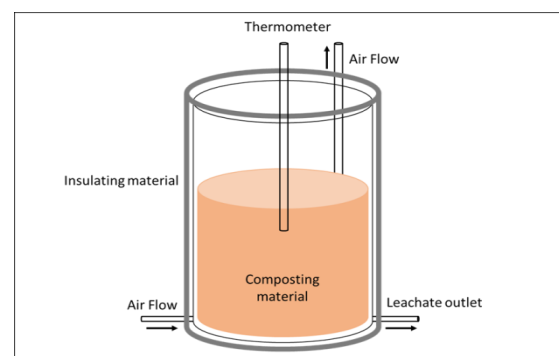


Fig5. Basic Design of In-vessel Composting Method.

Normally, composting of organic waste will produce unpleasant smell due to the production of Volatile Sulphur Compound (VSC) during the decomposition process. However, a study performed by Yuan et al., (2015), proved that degradation of uneaten vegetables, fruit peel, an uneaten portion of meal, leaves and corn stalk in 20 L of wrapped stainless steel cylinder can be completed in 28 days without producing any unpleasant smell. This is because the addition of corn stalk in composting materials has high carbon content and acts as the bulking agent that controls the percentage of moisture content [61].

ICM was recommended as one of the rapid composting techniques that can be implemented both in small- and large-scale areas. Not only it can reduce the food waste transform them into useable compost in the shortest time, but it does not emit bad odour during the degradation process.

When compared between these three rapid composting methods, each method has their own benefits and limitation in the perspective of individual requirement such as the design of composter, volume of composting materials, budget and etc. Table 2 shows that BCM capable to process high volume of waste but it required quite large space and high labour to conduct the composting. Meanwhile, TCM and ICM are more suitable for small scale community like household since it does not need much space and more portable to be placed anywhere. However, ICM is expensive since it implements forced aeration in the system, thus it consumes high electrical cost compare to the other methods.

Table 2. Comparison between BCM, TCM and ICM.

Parameters	BCM	TCM	ICM
Design	Pile: 1m x 1m x 1m	Breathable covered container lined with cardboard	Enclosed container covered with insulating material
Composting materials	Green material, brown material and animal manure	Food waste, fermenting solution and fermenting bed	Food waste and bulking agent
Volume	≥ 200 kg	≤ 20 kg	≥ 20 kg
Reduction	53%	68%	50%
Cost	Cheap	Cheap	Quite Expensive
Space	Not too small	Small	Not too small
Labor	High	Low	Low
Rapid	Yes, by following five standards requirements	Yes, with the help of effective microbes (EM)	Yes because of the parameters control

*EM: Effective Microbes

Overall, all the method proposed here were effective to transform food waste into high quality compost in the shortest time due to specific techniques applied in the system such as balanced composting materials, good aeration, addition of EM and particular in the monitoring of essential parameters during composting.

IV. CONCLUSION

This paper highlighted the significant drivers that contribute to the amount of food waste in Malaysia. By identifying the main factors of food waste, the government can formulate strategies and approaches on preventing the food waste in each level comprises of the agricultural sector, industrial production and manufacturing, markets and also from the household stream. Further research is required to investigate in details the other external factors responsible for this issue. Feasible management from the government is crucial to prevent more food waste in the landfill.

This paper also highlighted three rapid composting methods specifically for food waste which were Berkeley, Takakura and In-vessel composting methods. Based on the findings, each method implemented different techniques to reach maturation phase in the shortest time such as balanced of C/N in the composting materials, good aeration, addition of EM and particular monitoring during composting. It was proven that these three methods are suitable to be implemented in both a large and small scale without negatively impact the environment. In fact, the end-use of composting can be used as a fertilizer. Therefore, it can be concluded that BCM, TCM and ICM can be used as an alternative method to treat the current and upcoming food waste in Malaysia.

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