A comparative study on generation and composition of food waste in Kundasang, Sabah

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Abstract. In this era, we are facing a very troublesome problem, and that is food waste. Food wastage started happening decades ago and is still happening today. This not only comes from large-scale food and beverage production but, unfortunately, also comes from people's behavior. Which had made the research to study the generation and composition of food waste in Kundasang, Sabah and identify the awareness of food waste management. the collection of the food waste involved in residential and commercial and then, divide into two types which are cooked and uncooked food waste. As a result, the food waste generated from the commercial was more than residential area. Then, the food waste generation rate for every person is 0.14 kg/person/day. Most of the people in Kundasang know about food waste management but they do not know the proper way to manage the food waste but 64 % of them, interest to involve minimize the food waste in the future. Knowledge and skills can be spread among family residents through sports and awareness activities related to food management. In short, appropriate methods should be introduced to overcome the restrictions on the residents of Kundasang's households to minimize food waste.

1. Introduction
Food waste is decomposable waste that is usually generated from the residential, commercial, and institutional areas. Food waste has raised global concern nowadays. In Malaysia, landfill is the most common method of solid waste disposal and up to 50% of landfill is containing with food waste [1]. Food production and utilization processes are highly inefficient nowadays. Food waste management is an important concern in developing cities because it is related to human health and also to the environment. When there is a large population in this area, it becomes a serious problem because a lot of human activities always produce food waste [2]. The fast population growth, urbanization, economic levels, and increase in the community living standards generates an enormous amount of food waste across the Malaysian municipalities [3].

The management and policy for food waste treatment are considered less efficient in the country due to limited budget for food waste management and less awareness for managing the food waste [4]. This existing food waste can be incinerated or dumped in open areas but causing serious health or environmental problem [3]. Therefore, appropriate methods are required for the management of food
Anaerobic digestion could be an attractive alternative to enhancing global energy security by using food waste to produce biogas while striving for waste management and recycling of nutrients [5]. Food waste also can manage by doing the composting, used as fertilizer, or animal feeding. Sabah is having a problem managing food waste, especially in rural areas because of the lack of awareness among the people. The special skills and knowledge gained from environmental education will help change human behavior towards the environment. People with certain environmental education knowledge and skills are more motivated to participate in environmental protection activities and plans, thereby generating new ideas for solving environmental problems [6].

The implementation of an efficient food waste management system needs detailed data for the preparation of an acceptable waste management system. The method for obtaining comprehensive data is by surveying the area and also composition studies. Composition is one of the manners to determine the amount and also each type of waste. By composition, we can also estimate the lifespan of the landfill [5]. Thus, this project is to study the generation and composition of food waste in Kundasang Sabah and also to identify the awareness of food waste management in Kundasang, Sabah.

This study was conducted at Kundasang located in the Sabah highlands. It was among the most popular tourist destinations in Sabah because of its proximity to Mount Kinabalu. Historically, Kundasang is a rural area, which has grown from a small town into a popular leisure place for visitors from all over the world. Therefore, the area has experienced increased development of resorts and homestay accommodation for tourism. The main work in Kundasang is with most of the villagers working as farmers and sellers of fresh vegetables at the small stalls in the Kundasang district. But because of the increase in development and tourism activities has affected the environment as rising consumption has increased food waste generation.

2. Material and methods

2.1 Sample collection
The study on food waste generation and composition at six different residential areas and one commercial area consisted of three main stages which are weighing the waste, recording the data and analyzing the data. The data were obtained by direct weighing of the food waste collected from six residents where it was generated throughout the day. The six residential areas involved are Kampung Dumpiring, Kampung Kinasaraban, Kampung Desa Aman, Kampung Sinisian, Kampung Cinta Mata and Kampung Lembah Permai labelled as residential areas as shown in Figure 1. There 20 restaurants in Kundasang District were labelled as commercial areas (Figure 2).

![Figure 1: Location of Sample Collection.](image-url)
Figure 2: Selected Location of Restaurant in Kundasang District.

The food waste collections were sorted, segregated, and categorized. The collection was divided into 2 types (cooked and uncooked) food wastes and was categorized into 9 categories (rice, vegetables and fruits, meat and fish, fats and oil, nuts and peanuts, bakery product, dairy product, eggs, and others [7]. The weight of each waste was weighed based on the waste component. The data has been estimated and recorded. To determine the Weight percentage of each waste component, this equation was used.

\[
\text{waste weight (\%)} = \frac{\text{weight of waste category}}{\text{total weight of waste}} \times 100
\]  

Per capita generation is determined as the total waste that is collected in a day and also the separated fractions using the formula:

\[
\text{Per capita waste generation} = \frac{\text{Food waste weight}}{\text{Total number of household} \times \text{Number of collection days}}
\]

2.2 Questionnaire

The respondents were the residents of the Kundasang district, Sabah. There were two respondent categories (Residential and Commercial Area). The questionnaire has distributed to respondents who agreed to be involved in this study [7]. The questionnaire consists of three parts with 20 questions. The language used in this questionnaire is English and Bahasa Melayu. The first part of the questionnaire consists of the demographic information of the respondents. The second part is on the knowledge of food waste and methods to manage the food waste. The last part of the questionnaire consists of questions of the respondent’s knowledge on the food waste produced and possible efforts that can be implemented to minimize the food waste. The data collections were then analyzed using Microsoft Excel.

3. Result and Discussion

3.1 Food Waste Generation

The total weight of the cooked and uncooked food waste generation among 60 households and 20 restaurants studied in six villages is shown in Figure 3. The highest generation is cooked food waste which is 156.3 kg from the residential area and 180.3 kg from the commercial area. People cooking or
providing too much food and this causes the wasting of the prepared food or instant food. The cooking part has increased over time, and large meals usually include more food than they consume [8]. Based on the results, total solid waste generation from the residential area is 274.2 kg which is involved 327 people and from the commercial area is 353.5 kg. As restaurants continue to grow, food waste from commerce is greater than for residential areas. This is because people rarely end up eating in restaurants. Often the worst offenders are wasting food in staff restaurants. A restaurant was estimated that, on average, 10% to 30% of food in Malaysia is wasted every day, and these consumers are unaware, and may not even care about how much food they end up wasting [9].

Figure 3: Weight the Type of Food Waste.
There is a difference in food waste generation in this study area. Average waste generation per household and per capita waste generation is 0.76 kg/house/day and 0.14 kg/person/day as shown in Table 1. Kampung Sinisian generated the highest waste compared to the other villages. The food waste generated can be influenced by the differences in the socio-economic status in Kundasang such as income level. In addition, the generation of food waste varies from city to city based on living standards, livelihoods, social and religious traditions, and people's eating habits [10].

### Table 1: Total Food Waste Generation from Household.

| Villages      | Total weight of food waste (Kg) | Average food waste generation per capita (Kg/household/day) | Average food waste generation per capita (Kg/person/day) |
|---------------|----------------------------------|-----------------------------------------------------------|--------------------------------------------------------|
| Kg. Dumpiring | 46.2                             | 0.77                                                      | 0.14                                                   |
| Kg. Kinasaraban| 43.7                             | 0.73                                                      | 0.13                                                   |
| Kg. Cinta Mata | 46.8                             | 0.78                                                      | 0.14                                                   |
| Kg. Desa Aman | 46.2                             | 0.77                                                      | 0.15                                                   |
| Kg. Sinisian  | 47.7                             | 0.80                                                      | 0.14                                                   |
| Kg. Lembah Permai | 43.6                            | 0.73                                                      | 0.14                                                   |
| Total         | 274.2                            | 0.76                                                      | 0.14                                                   |

Figure 4 showed the food waste composition in the six villages. Vegetables and fruit were 25% of the food waste, which is higher than other categories followed by dairy products, meat and fish, bakery, eggs, rice, and others. The lowest value generated is nuts and peanuts. Observations of the process of food waste collection and sorting show that residents’ eating habits include a variety of agricultural products, including vegetables such as broccoli, spinach, tomatoes, and cabbage, and fruits such as apples, bananas, and mangoes. The consumption of carbohydrates also varies, because waste also includes rice, noodles, bread, potatoes, and various beans. In addition, protein wastes such as eggs, seafood, and meat fat residues are also among the various types of food wastes observed, as well as small amounts of eggshells, beans, and used tea/bags. These observations and the amount of wasted food indicate that residents not only have access to a variety of nutritious foods but also a large amount of food, thus highlighting the problem of oversupply and waste of resources. Unfortunately, food waste is a key indicator of sustainability because it represents the number of resources wasted to produce uneaten food during the entire food production process. In addition, food waste also contributes to greenhouse gas emissions during the decomposition process [11].
Figure 5 illustrated the food waste composition from the commercial area where the result is quite similar to the residential area, but a bit higher of 27% vegetables and fruit than other categories. One of the main reasons is Kundasang area the main economy is on vegetable cultivation and most of the restaurants serve fresh vegetables on their menu. But the result of other categories is not the same as residential areas. Rice, meats and fish are in the second position in the commercial area at 18% of the total, while the lowest generate is nuts and peanuts which are 1%. The shows both in both areas the nuts and peanuts are not much consumed in these areas. However, a large amount of food waste of nuts and peanuts occurs in the processing stage and is estimated to account for 34% of the entire industry's investment. This waste is mainly an inedible by-product of cracking. It is a nut-type shell. These shells are removed during the manufacturing process. Although some nuts are sold in the shell but generate very low waste [12].

![Figure 5: Food Waste Category from Commercial Area.](image)

3.2 Awareness of Food Waste Management

Based on Figure 6, most of the respondents were aware of food waste management and 24% were ignorant. They are less conscious of the campaign for food waste management in the Kundasang area. Unlike other recyclable garbage such as paper and glass, a program for the separation and reduction of food waste is not yet fully utilized in this country, Malaysia, due to a variety of difficulties such as a lack of awareness about the food waste problem among waste producers [10].

Therefore, 82% of the respondent agree that food waste can cause environmental and hygiene problems around their housing area. Food waste is not good for the economy or the environment. The consequences of improper disposal of food waste can cause an unpleasant smell, attracts rodents and animals, and affects the aesthetic view in a residential area [1]. Agricultural products that cannot be eaten due to the following reasons its abnormal shape or size remains in the field. This discarded food Rotten rather than compost properly. About 10% of Greenhouse gases come from food that has been grown but not being eaten [9].
The prevailing reason for the generation of food waste in Kundasang is that the food waste is inedible which is the remaining part of vegetables and fruits, followed by the food was spoilt or had passed its “use-by” date as shown in Figure 7. Pack the most food should have the best date. Even a bottle of water deadline. Most people throw away the food before the best date. Many people mistakenly believe that they will be poisoned if the food they eat has passed the expiration date. Although your food may no longer be as fresh as when purchased, may be eaten in a few days or weeks. Insufficient storage means that food has spoiled too early. In fact, in poor countries, food often deteriorates before it leaves the farm [13].

Data in Figure 8 was obtained from respondents on methods of food waste management. It shows that most of them use food waste as animal feed, which is 46.5 % used as animal feeding, while 17 % of the respondents always avoid cooking too much. Furthermore, the separation and reuse or recycling rate are higher. Most of the place in Kundasang is a rural area, therefore, it is easy for them to use the food waste as animal feed. 70 % of approximately 197 tons of food waste per year are treated as livestock feed. of the 10,610 tons of waste generated by each vegetable, about 50 % come from one year for livestock,
especially pigs. In addition, the by-products are industrial firmware that can be used in animal husbandry [14]. The practice of feeding food waste to animals has not been completely abandoned. In the United States, there are currently many processing and feed production facilities that can switch food waste from various food supply chain sectors to animal feed such as harvesting and processing or manufacturing [15].

Several challenges to manage food waste shown in Figure 9. Time constraint was found to be the main challenge for post-consumption stage food waste management. About 26% of the respondents claimed that the lack of time was the main reason for them to not put any effort into reducing food waste. Time constraints in their daily schedule did not allow them for any practice of food waste reduction. They lack time to manage the food waste because most of them are busy with work or study since they still work from home for this covid19 outbreak. Time and cost mentioned as an obstacle to food waste management, which can be further classified as an economic factor [16]. Despite a lot of improvement efforts. In the domestic organizational process, many interviewees still view this area as a weakness. Mainly due to time constraints caused by heavy workloads, leading to lack of time for family management people often use it as a cause of food waste. Family rules with children food waste is due to the behavior and preferences of children and teenagers, which should be important target groups for prevention activities. Need for early childhood education on food issues always emphasize waste [17].

Figure 8: Method to Manage the Food Waste.

Figure 9: Challenge to Manage the Food Waste.
Figure 10 reflects the motivation of respondents on whether food waste minimization. Most of the respondents think that they might get themselves involved in minimizing food waste in the future. Meanwhile, 67% of the respondents will most likely participate in minimizing food waste in the future. Any future laws requiring the practice of keeping household kitchen waste minimum and its importance may also cause them to want to be involved in the future. We can summarize that 52% of the 100 respondents was suggested possible efforts that can be implemented in the future to minimize food waste is install the food waste disposal unit. In some countries, food waste is segregated at home which will then be treated biologically by composting or anaerobic digestion. Anaerobic digestion (AD) is one of the biological treatments for organic waste that is gaining growing popularity because of its high waste value. AD of organic waste provides opportunities for energy recovery and nutrient recycling opportunities [4].

![Motivations to Minimize the Food](image)

Figure 10: Motivations to Minimize the Food.

Figure 11 shows that the awareness of the respondent about food waste management. Most of them are aware about food waste minimization can help to conserve and sustain sources for the future and they know the effect improper food waste management. Only 18% of the respondent strongly agree that food waste is the sole responsibility of the local authority. Food waste management is not just the responsibility of the local authority, but also the responsibility of all people. However, it is necessary to further systematically evaluate the impact or contribution of other actors such as non-governmental organizations or foreign aid to society and the economy, and the extent to which the public can be encouraged to implement recycling or other waste minimization practices. There is still a need to educate the general public and families on how to correctly classify waste, and effective implementation of public education strategies and methods must be tailored to the target audience [18].

Organize proper infrastructure used for food waste recycling, in other words, to improve convenience for homes and business places continuous understanding of the source classification of food waste Raise funds through education, flyers, and local and national the media is important. Successful public participation and effective participation in the food waste recycling program is a major concern to local authorities [2].

Then, only 15% of the respondent that knows the proper way to manage the food waste. this is because of a lack of disclosure about food waste management. Some of them do not know the proper way to manage food waste. Challenges that involved to minimize the food waste are lack of awareness on home composting, lack of authorized facilities, such as civic amenity sites or transfer stations sites accepting segregated food waste, and more enforcement of checking waste loads to ensure food waste
is not included in general waste stream from areas where food waste regulations apply [2]. Proper management of food waste helps save the planet and save energy was strongly agree by 57% of the respondents. The reason given was that the environment will be cleaner if the food waste is segregated from other household waste. 30% of the respondents have known the effect of improper food waste management and 54% strongly agree that food waste minimization helps to conserve and sustain sources for the future.

![Figure 11: Respondents’ Knowledge on Food Waste Minimization.](image)

**4. Conclusion**

This paper was conduct at Kundasang as a case study to clarify the current situation and trends in food consumption and food waste generation. we can summarize that the food waste generation rate for every person is 0.14 Kg/Person/Day and the type of food waste is cooked and uncooked food waste and the category of food waste generated is fruit and vegetables, dairy product, eggs, rice, meat and fish, fats and oils, nuts and peanuts, and bakery product. This study found that the level of food waste generation is high in Kundasang even when compared with the developed town, but is not being managed appropriately, while the national government has put some of laws, legislation, and strategies into effect and outlined ambitious targets for food waste management, there is a lack of implementation at the local level. 76% of the respondents are aware of food waste management but only 15% of them know the proper way to manage the food waste, even though they know that the food waste can cause environmental and hygiene problems. The main reasons for wasting food at home are that food is inedible which is the remaining part of fruits or vegetables. On the other hand, the top three potential obstacles to minimizing food waste are a time limit, lacking of food waste management knowledge and they do not realize that this is a problem. Some of them also think that no law enforcement to minimize food waste. The challenges discourage the respondents to minimize food waste in the home.

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