ENVIRONMENTAL ASSESSMENT ON DAILY OPERATIONS OF THAI FOOD RESTAURANTS AT KOTA BHARU DISTRICT.

ABSTRACT

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Food losses occur across the whole food supply chain comprising the final stage that pose negative environmental impacts due to the emissions of GHG including carbon dioxide and the use of drinking water. The rising in number of food industry including restaurants lead in increasing of waste generated as this sector produces high amount of food waste compared to households. Thus, this study was conducted to evaluate the environmental assessment on daily operation of Thai food restaurants. Since restaurants is the place where food is served, consumed and wasted, it confer an ideal scenario to study food systems at consumer level. In order to get more reliable and detailed data of food losses in this sector, the food waste generated from 5 selected Thai food restaurants with the same criteria selection were classified into three categories (preparation losses, serving losses and plate waste) and measured for a period of one-week. Three separate bins were made available for Thai food restaurants selected for the collection of food waste generated. The weighing of food waste according three categories of losses were carried out onsite by using weighing scale and the data was recorded. Then, the Material Flow Analysis (MFA) was performed to determine the amounts of food waste generated in the form of diagrams and the factors contributed most significantly to these amount. The findings presented that customers' plate waste contributed to most of the food waste which is 11.29 % in total waste on daily operations of Thai food restaurants compared to preparation loss that generated only 6.88 % of food waste. The highest in daily average number of food waste generated was on weekends compared to other days for both preparation losses and plate waste that attributed 8.32 kg and 12.60 kg respectively. The high amount of energy consumption on weekend had contributed to the huge total carbon emissions in this study that were recorded for 9.87 kg CO_2 and 11. 421 kg CO_2 respectively. The water consumption during weekend also revealed the highest contributor to the total

carbon footprint emissions, which was accounted to 2.6 m^3 of water consumption and emitted up to 0.89 kg CO_2 which is 24.52% of the total emissions. Thus, the measure such as improving the energy and water use and food waste from restaurants' operation can ensure operating emissions is lower and more efficient.

Keywords: Food service, daily operations, food waste, carbon dioxide (CO_2) emissions

1.0 INTRODUCTION

Food waste has formidable negative impacts on food security, the environment additionally economy, which makes global challenge that requires critical considerations. One third of food produced globally for human consumption is lost or wasted for nearly 1.3 billion per year (Papargyropoulou et al., 2019). There are various environmental impacts due to large amount of food waste as they emitted greenhouse gases (GHG) that can lead to climate changes during their decomposition at the landfill (Thi et al ., 2015). Nowadays the rising in number of the restaurant industry has contribute to direct negative impacts towards the environment such as energy use, solid waste generation, air and water use and carbon dioxide (CO_2) emissions .The food service sector is one of the great diversity, including restaurants, cafeterias and hall of residences. Pirani & Arafat (2014) claimed in their studies that food waste from food service sectors are most generated other than household. Restaurants and cafeterias are increasingly popular in developed countries and one of the sources of food waste generated in the world.

Waste from the restaurants are derived within the preparation process of food such as cutting and peeling of raw material, kitchen error and food leftover in plate. In addition, other contributing factors to food waste generation are serving style such as buffet style or a la carte, types of serving and accuracy in predicting of expected customer to serve (Holly, 2014). Malaysia is well-known for diversity of dishes and unique food culture. Unfortunately, the unique food culture also turn into a culture of waste. From an environmental point of view, when food is lost or wasted, the resources that being used up for food processing such as energy and water usage are also wasted. In Malaysia, solid waste is a major environmental problem and

increasing waste generated can pose various problems because improper practices and management can leads to pollution, resources degradation and health problems for humans and animals.

The food service sector is known to be the fastest growing sector and the development of the restaurant industry in Malaysia are expected to grow more in the future. Multiple choices of restaurants are available within the country such as western restaurants, casual dining restaurants, Asian type restaurants including Thai food restaurants and fast food restaurants that serve variation of food which makes customers able to choose variety of foods provided. However, the growing of food service sector may leads in increasing of waste generated as it is one of the sector that produces high amount of food waste (Pirani & Arafat, 2015). Besides, the arising of food waste in restaurants are derived from preparation stage, this is because most of food handlers prepare meals traditionally using raw materials. The use of raw ingredients leads to prolonged meals preparation time and when inaccurate demand exists, larger volumes of wastes are to be expected. Most of the previous studies have concentrated on commercial restaurants, which have primarily studied the trend of waste from society and compositions of solid waste. However, this study has taken into more specific approach, which focuses on Thai food restaurants and food waste generated within the preparation, serving and customer plate during daily operations. During the food waste audit, the amount of food waste based on the preparation, serving and customer plate was assessed and reported continuously throughout the day and continuously for approximately one week.

In addition, this analysis is restricted only to food that is lost at the stage of food service by preparation, serving and consumption. The aim of the selected case

studies was not to provide a detailed image of the total food waste produced in restaurants, but rather to provide opportunities for testing how these variables affect the generation of food waste. This analysis does not include food that has been lost at any other point of the food supply chain, including production, post-harvest handling and storage, packaging, distribution and retailing, or food taken off-premise by home-consuming customers. It also did not involve the collection and final disposal of waste at landfills or waste treatment plants. The waste of oil and liquid waste also exempted from this study. As such, only food waste that exists within the restaurant boundary is included in the framework of the case study. Therefore, this study seeks to evaluate the environmental assessment on daily operations of restaurants, adopting material flow analysis (MFA) approach in order to analyze the flow of food waste generated at restaurants. By conducting this study, food waste problems in the food sectors can be more understood. Besides, through this study, the water footprint and carbon footprint emissions can be determined and the data obtained can be used by restaurants' management to reduce the impact towards the environments.

2.0 METHODOLOGY

A four-phase method was used in order to derive research results which are (phase one: preparation, phase two: implementation, phase three: waste audit and phase four: data analysis). The summary strategy of this study works from phase 1 until phase 4 can be described in Figure 1. Phase one which is preparation phase refers to the process for the preparation of the checklist and selection of Thai food restaurants while implementation phase focuses on the observation required in order to identify waste generation factors and waste disposal method at restaurants and footprint data. While, next stage is waste audit where the waste collected was being weighed and examination of recorded data based on the checklist. The final stage focuses on analysis of data obtained. Figure 2 illustrates data collection plan for methodology flow in assessment on daily operations of Thai food restaurants.

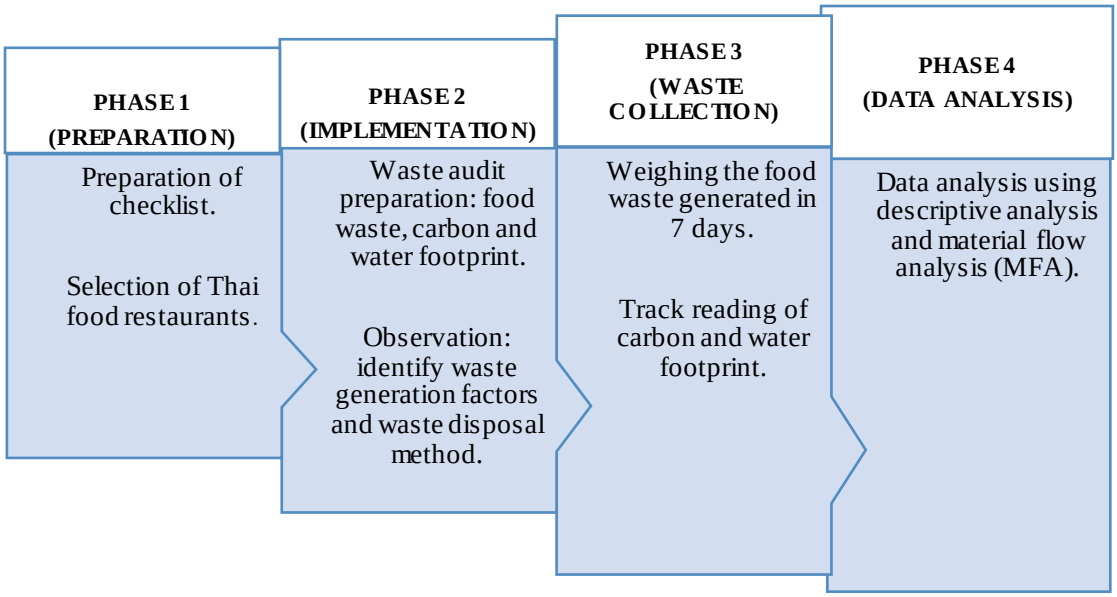

Figure 1. Phases in carrying out this study.

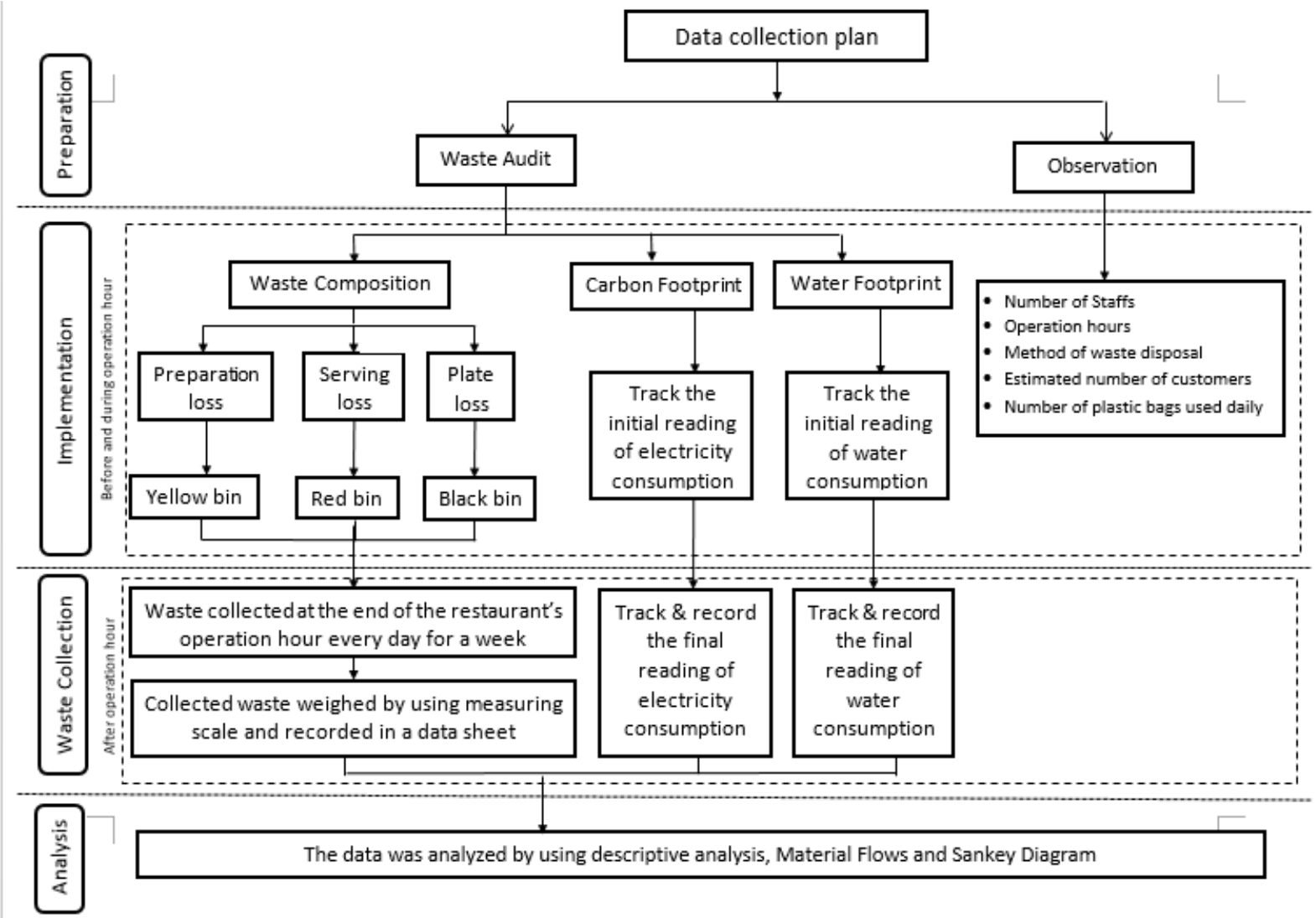

Figure 2. Data Collection Plan.

2.1 Phase 1: Preparation of Checklist

Firstly, a well-designed checklist was prepared to meet all specific objectives of the study (Appendix I). The data collected through the checklist contained all the information needed which included the number of staffs, operation hours, method of waste disposal, estimated daily number of customers, number of single plastic bag used daily, electricity consumption and water consumptions. For the electricity and water consumptions, the reading of the meters were taken before operations and after the operation hour. Students were required to communicate with the owner of the restaurants, who is wholly responsible for the record keeping to complete the checklist prepared. This is because all the data sources were routinely collected and stored by the owner of the restaurants.

2.2 Phase 2: Implementation

This stage involves collection of data from waste audit on food waste produced at selected restaurants. It takes about one week to conduct waste audit for a restaurant. Engstrom and Carlsson-Kanyama (2004) in their study claimed that in order to encourage harmonization of acquisition methods, losses can be divided into four categories which are storage losses (STOR), preparation losses (PREP), serving losses (SERV) and plate waste (PLATE). In this study, only three categories of losses that had been carried out which are:

1. Preparation losses (PREP) - losses occur during food preparation and cooking such as fruit and vegetables peel or spoiled food, collected prior to and during cooking time.
2. Serving losses (SERV) – food left from buffet or serving bowls at the bar, obtained after hours of service.

3. Plate Waste (PLATE) – residue left on customers' plates that collected after the operation hours.

Three separate bins with different color coded were made available for Thai food restaurants A, B, C, D and E for the collection of food waste generated relating to the preparation losses, serving losses and customers' plate waste. During this phase, footprint data which is carbon footprint and water footprint data were also collected where the initial reading of electricity and water consumption were recorded. Besides, some visual observation was performed to observe and analyze waste generation factors and disposal techniques at the restaurants. The awareness among the workers regarding food waste generation and method of waste disposal were observed.

2.3 Phase 3: Waste Collection

In this phase, the waste was collected at the end of the restaurants' operations hour daily for a week in order to account for daily variation (World Resources Institutes, 2016). After that, the waste that being collected was weighed by using measuring scale. The calibration procedure was performed prior weighing the food waste. This procedure was carried out onsite and all data obtained was recorded in the checklist. In addition, the final reading of electricity and water consumption were also recorded in this phase (Appendix II).

2.4 Phase 4: Data Analysis

Data analysis was conducted after all the information required from all Thai food restaurants. Quantification of food waste was carried out by means of a waste audit to assess the quantity and type of waste (Quested et al., 2011). Food waste produced in restaurants were documented and linked to a specific type of loss category

(preparation, serving and plate waste). This allowed conclusions to be drawn about the most wasteful process in the restaurants and the food types that had contributed most to the wastage. The material flow analysis (MFA) methods was performed to determine the flow process of food waste produce and identify the stage where high food waste is potentially occur. Carbon emissions and water footprints produced in the restaurants were calculated by using specific formulas in order to refer the amount needed before calculate the value (Mekonnen and Hoekstra, 2010, 2011). Then, Microsoft Excel also was used to analyze the data or to look into the pattern of the data. For each food waste generated based on preparation losses, serving losses and plate waste was calculated for one-week study period. Total quantity of food waste generated in each category was summed and reported as percentage of total weight of food waste.

2.5 Quantification of carbon footprint

Carbon footprint refers to the cumulative amount of greenhouse gases produced by operation, process and product. According to the Kyoto Protocol, there are six greenhouse gases (GHGs) which are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and hexafluoride sulphur (SF_6). In order to quantify carbon emissions from an operation or process, two parameters are needed. The first is activity data (AD), which indicates the process quantification. Unit measurement data is allocated to the operation data of the company. The other parameter required is the emission factor (EF) that indicates how much CO_2 emissions are emitted for an AD unit. For the purposes of the calculation of the carbon footprint of the process or consumption of goods (Malek & Kumarasan, 2019), the main equation is developed by the researchers as shown in (1):

$$\text{Carbon footprint (kg } CO_2e) = \text{Activity data (AD)} * \text{Emission factor (EF)} \quad (1)$$

The emission factors used in this study are shown in the Table 1:

Table 1. Emission factors for each activity data.

Activity Data	Type	Unit	GHG	Emission Factor
Electricity	Malaysia (commercial rate)	Kilowatt-hours (kWh)	kg CO_2 e	0.10919
Water Consumption	Water Supply	Cubic meters (m3)	kg CO_2 e	0.344

The emission data is crucial to obtain the total carbon emissions generated within the food establishments. Table 1 shows the emission factors for each activity data that acquired based on direct measurement of processes or by publicly available data such as GHG conversion factors from the United Kingdom Department for the Environment, Food and Rural Affects (Defra) or the Department of Energy and Climate Change (DECC) (Hill, 2011). The emission factor for electricity activity data based on Malaysia commercial rate is 0.10919 kgCO_2e/kWh while the emission factor for water consumption is 0.344 kgCO_2e/m^3.

3.0 RESULTS AND DISCUSSION

3.1 The food waste generation by different losses categories on daily operation.

This assessment was intended to determine the amount of food waste generated by different losses categories which are preparation losses, serving losses and customers' plate waste on daily operations of Thai food restaurants. This study was undertaken onsite at five selected Thai food restaurants with the same criteria selection within one-week period to obtain the daily data on food waste generated at the restaurants. Three losses categories which are preparation losses, serving losses and customers' plate waste was weighted by using measuring scale and the reading was recorded . Table 2 depicts the daily average for five selected Thai food restaurants according to losses categories.

Table 2. The daily average for Thai food restaurants according losses categories.

Type of loss/waste	**Day/kg**							**Average Total Weight (week)/kg**
	1 (Sunday)	2 (Monday)	3 (Tuesday)	4 (Wednesday)	5 (Thursday)	6 (Friday)	7 (Saturday)	
Preparation Loss	6.52	6.24	6.40	6.18	6.44	8.32	8.08	48.18
Customers' Plate Waste	10.84	10.23	11.35	10.29	11.69	12.60	12.02	79.02
Total Weight of food loss/waste/ kg	17.36	16.47	17.75	16.47	18.13	20.92	20.10	127.20

*Serving loss is not applicable for Thai food restaurants.

Table 2 details the daily average for five selected Thai food restaurants according to losses category. It was noted that there were two major losses categories which are preparation losses and customers' plate waste that altogether contribute to the food waste generated at Thai food restaurants. A total of 79.02 kg and 48.18 kg of the average of food waste had been generated within one-week period for customers' plate waste and preparation loss, respectively. The comparison between preparation loss and plate waste shown the amount of plate waste was significantly greater than the preparation loss within the five Thai food restaurants from day 1 until day 7 (Sunday until Saturday).

The results obtained agreed with the previous work carried out by Drewitt (2013) that majority of cooked food that being wasted were from customers' plate waste rather than pre-consumption waste because in restaurants like Thai food restaurants, food is generally made to order. The serving loss was not measured in this study due to food not being served in buffet style like casual dining restaurants. The highest in daily average number of food waste generated is on Friday (weekend) as compared to the other days for both preparation losses and plate waste which are, 8.32 kg and 12.60 kg respectively. Since this study was conducted in states of Kelantan, thus the weekend is falls on Friday and Saturday, though in other states and territories with a Saturday-Sunday weekend. The food waste generation at Thai food restaurants can be attributed to various factors such as the type of ingredient used and the opening hours (Principato et al., 2018).

During pre-consumption phase, food handlers at restaurants required to prepare multiple dishes of Thai foods. Vegetables peels, egg shells, meat bones and fruit peels are derived from the preparation stages that can lead to the major food waste during

this stage. As mentioned in Table 2, the average total weight in kg for preparation loss in a week is 48.18 kg. Nevertheless, from day 1 until day 7, the total amount of food waste generated on weekends (Day 6 and Day 7) had contributed 16.4 kg to the total amount of food waste generation at preparation stage. While, the other days, the total food waste for preparation loss is about 6.36 kg in average. This result clearly shows most of food waste generated on weekends compared to the weekdays.

Thai food restaurants had the biggest problem with post-consumption food waste, which accounted for 79.02 kg of all food waste produced. Through onsite observations, it was immediately obvious and that people were ordering a lot more food than the café or western type of restaurants. Patrons were leaving behind a large amount of food on their plates often around 10-12.60 kg. Most of the patrons were leaving behind all different types of food, but there was clearly a high incidence of rice and vegetables dishes being left behind on plates. This fact was supported by Engström and Carlsson-Kanyama, (2004) and Al-Domi et al., (2011) which stated the plate waste was found to encompass largely of starch accompaniment followed by vegetables. This finding was also being supported by previous studies conducted by Thyberg & Tonjes (2016) that found out that the plate waste is significant contributor to food waste. The amount of food waste generated on weekends are higher compared to another days for both preparation loss and customers' plate waste. Based on the onsite observation, the number of patrons on weekends is higher to be compared during weekdays. Most of the patrons tend to bring their families and children to dine in the restaurants on weekends as during weekdays they usually take away the foods. Thus, the customers' plate waste much higher on weekends and as well as preparation loss.

Generally, post-consumption food waste is a combination of consumers' attitudes and behaviors (Drewitt, 2013). Others, a study conducted by WRAP (2013) that involved interviewing the customer regarding most recent eating-out experience, found that main reasons why patrons leave food behind on their plate because they believe that the portion sizes were too big. Of all diners who left food on their plate, 41% said it was because the portion size was too big. Not only that, large portion size certainly not the only reason why patrons leave behind plate waste but also depends on the eating behavior of consumer. The study also found that diners who ate out in restaurants were more likely to leave food on their plate than those who went out to other venues such as fast food restaurants, where presumably they were more likely to be eating-out simply to refuel.

3.2 Material Flow Analysis (MFA) on daily operations of Thai food restaurants.

The study then detailed to implement material flow analysis (MFA) approach to identify actual food waste materials flows from the point of food input. This MFA approach was performed to determine either preparation loss or customers' plate waste that contributed to large amount of total food waste in the restaurants as shown in Figure 3.

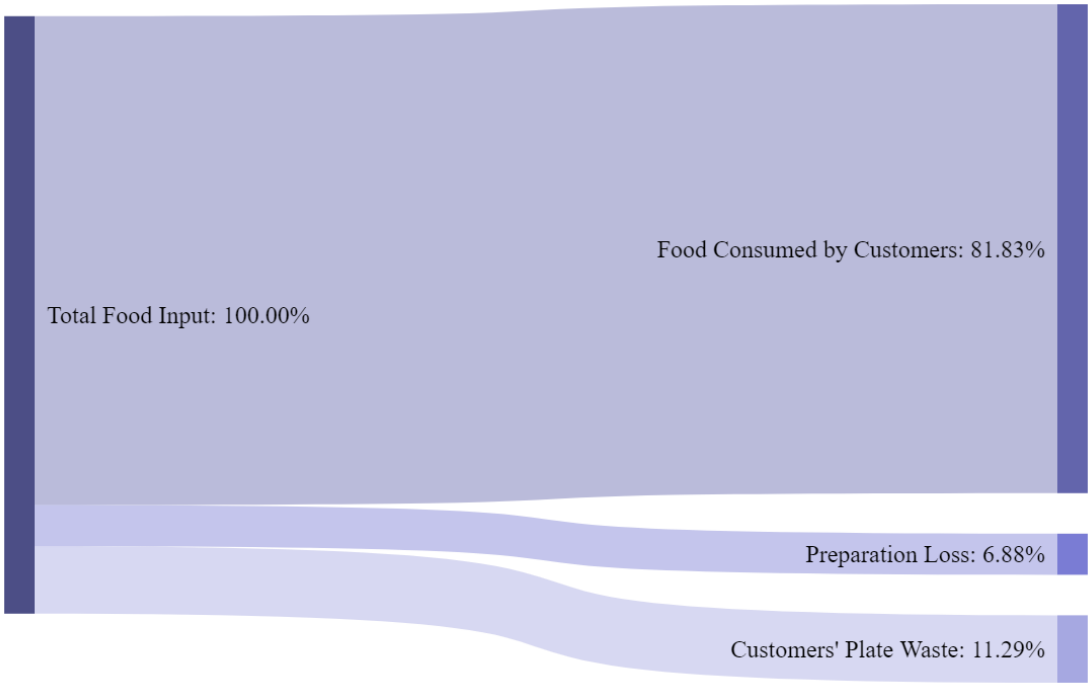

Figure 3. Material Flow Analysis (MFA) on daily operations of Thai Food Restaurants.

For Thai food restaurants, food essentially undergoes through four major steps which are storage, preparation and cooking, serving and consuming. Food waste can occur at any stage along this process. However, only preparation loss and customers' plate waste that included in this study. Rough estimations were made about the weight proportion of food consumed against food wasted in restaurants in order to develop material flow analysis diagram. The Material Flow Analysis (MFA) diagram was performed by using SankeyMATIC (BETA) software to visualize the magnitude of the material flows taking place within Thai food restaurants. The thickness of each link represented the amount of flow from a source to a target node, which is from the total food input to food consumption. The flows are presented in % rather than kg/day to facilitate the comparison between losses categories. MFA on daily operations of Thai food restaurants illustrates that food waste accounted for preparation loss and customers' plate waste which are, 6.88% and 11.29% respectively. The average food

waste rate was lower than the average 18% reported by Beretta et al., (2013) and 20% reported by WRAP (2013) in their previous studies. Preparation losses also considered as pre-consumption stage of food waste generally consists of vegetables peeling, egg shells and off-cuts resulting from preparing and cooking the local menu items. The results identified from MFA approach is helpful to put the quantity of food waste produced in to context, and to fully understand the extent of the food waste problem.

3.3 Amount of carbon footprint emission from daily electricity consumption in Thai food restaurants.

Data on the total amount of electricity consumption at Thai food restaurants were collected from electricity meter reading prior operations hours and after the operations. All the data sources were routinely collected and recorded for one-week period. The average daily electricity consumption data for five Thai food restaurants were collected in kWh of electricity consumed as recorded in Figure 4.

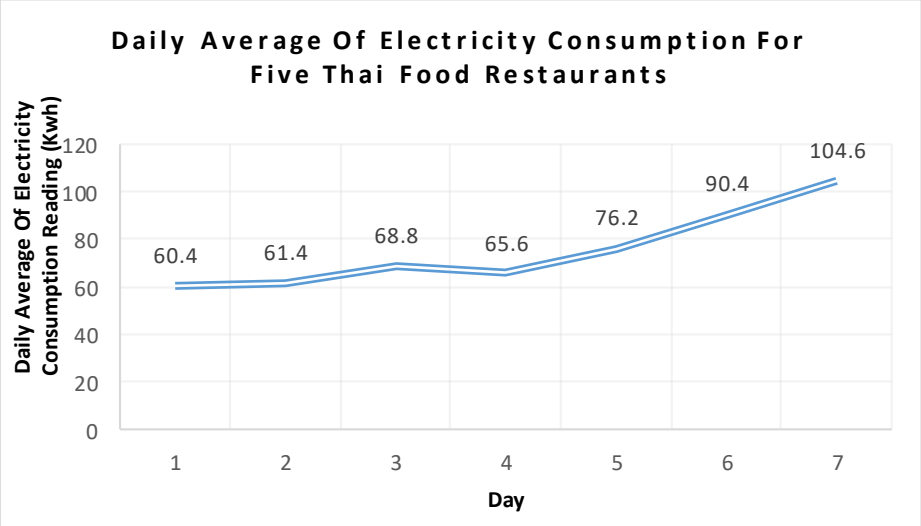

Figure 4. The daily average of electricity consumption for five Thai food restaurants, (kWh).

Considering the restaurants selected with the same criteria selection, Figure 4 clearly demonstrates that weekends are by far the largest use of daily electricity compared to others days. The Thai food restaurants contributed to the largest use of electricity on Friday (Day 6) and Saturday (Day 7), which are 90.4 kWh and 104.6 kWh respectively. From the data collected, calculation of CO_2 emissions was done using equation (1) and then the result obtained was tabulated in Figure 5.

Carbon footprint (kg CO_2e) = Activity data (AD) * Emission factor (EF) (1)

Emission factors were used to indicate the total amount of CO_2 emissions that emitted for an activity data. This emission factors may be determined by direct measurement of processes or by publicly available data from Defra and DECC (Hill, 2011). The emission factor for electricity based on Malaysia commercial rate is 0.10919 kg CO_2e/kWh. Figure 5 illustrates the daily average of carbon footprint from electricity consumption at Thai food restaurants from Sunday until Saturday.

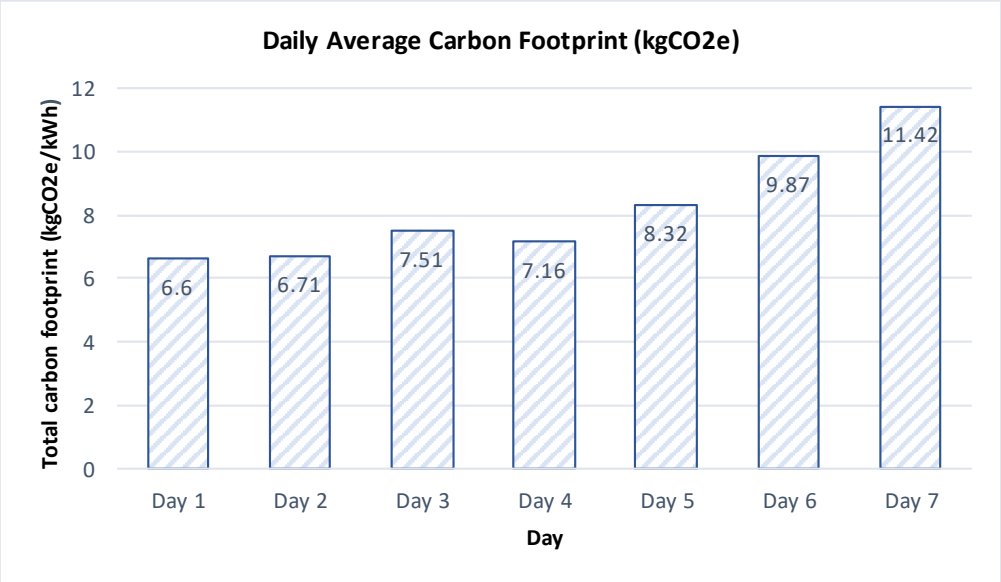

Figure 5. The daily average carbon footprint for Thai food restaurants, (kg CO_2e/kWh).

Based on the calculation for carbon footprint, the largest contributor to total carbon emissions in this study was during Saturday (Day 7). On this day, it consumed up to 104.6 kWh of electricity consumption and emitted up to 11.42 kg CO_2 which is 19.83% of the total emissions. Next, the second largest contributor to total carbon dioxide emissions was during Friday (Day 6), accounting for 17.14 % of total emissions. Restaurants operation had emitted 9.87 kg CO_2 during Friday and it is second highest to emit carbon dioxide could be due to the often usage of electricity consumption during the operation hours. The finding also indicate that during Sunday and Monday emit 11.45 % and 11.64 % of total carbon dioxide emissions respectively. During Sunday 6.595 kg CO_2 was emitted and it is slightly lower compared on Monday which emitted 6.704 kg CO_2 aligned with their amount of energy consumed.

The electricity consumption by Thai food restaurants from Sunday until Thursday was low with an average consumption of 66.48 kWh per day as compared to the average electricity consumption on weekends which at 97.5 kWh per day. This is

because as the number of patrons during weekdays is fewer compared to weekends, the energy consumption during that period is expected to reduce as the number of consumers would be low. Based on visual observation, the high usage of energy consumption during weekend is due to huge amount of electricity consumption required for more eating spaces within operation hour. While the total carbon emissions on weekends are the largest contributor to the total carbon emissions in this study which are, 9.87 kg CO_2 and 11. 421 kg CO_2 respectively that contributed to 17.14 % and 19.83 % of the total emissions subsequently.

Environmental impacts are attributed to food waste, for example, carbon emissions are one of the rising issues in food industry including Thai food restaurants since food waste claims high carbon and water footprint that give negative impacts. Due to the fact that carbon dioxide is the major GHG that contributes to global warming, this study aims to calculate the carbon dioxide emissions from electricity consumption. Carbon footprint of a food product is the total amount of GHG emitted throughout the life cycle of that product, expressed in kilograms of CO_2 equivalents (kg CO_2e). Chand et al., (2016) claimed the energy consumed by end-users are commonly evaluated in three different categories namely air conditioning, domestic water heating and electrical appliances and lighting.

Regarding the consumption phase, it is considered that the GHG emissions are related to energy used to cook or to store the food in a fridge or freezer. From the data obtained, kitchen areas which involved cooking process shows the greatest of CO_2e emissions where the majority of cooking is undertaken using equipment powered by electricity. Not only that, the impact from ventilation systems needs to be taken into account as one of the contributing factors to the electricity consumption within

restaurants. Besides, a wide range of equipment for lighting that was switched on at the start of a shift and left throughout the day until the operations ended also contributed to the electricity consumption in the restaurants. Not only that, considering the amount of energy consume in the restaurants during non-operating hours to operate the refrigerators or freezers daily, it also contribute to the high usage of electricity.

There will be a lot of negative consequences when using excessive amounts of energy without concerning their detrimental impacts to the climate, future generations and environment. Behavioral change in the consumption and utilization of energy is required in order to address the threat posed by carbon emissions. Thus, it was crucial to properly document and logged the energy consumption within food service sectors so that the carbon emissions can be well controlled and monitored.

3.4 Amount of carbon footprint emission from daily water consumption in Thai food restaurants.

The results for daily water consumption in Thai food restaurants were recorded prior operation hour and after the operation hour. All the data sources were routinely collected for one-week period. The daily average for water consumption in five Thai food restaurants were documented as shown in Figure 6.

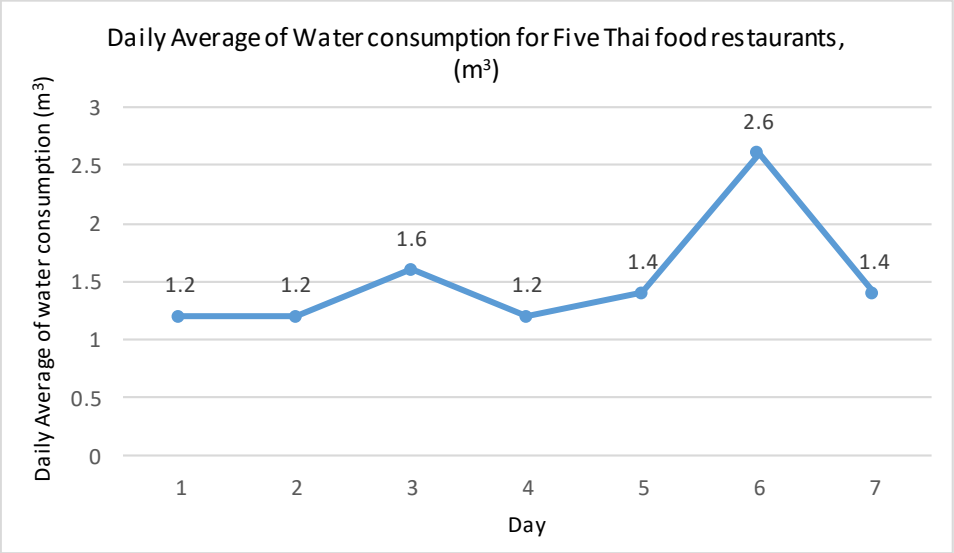

Figure 6. The daily average of water consumption for five Thai food restaurants.

The reading for water consumption on Sunday and Monday remained constant with 1.2 m^3 of daily average water consumed. The highest water consumption on daily operation of Thai food restaurants is on Friday with 2.6 m^3 of daily water consumed. There is sharply increased of water consumption during the restaurants' operation on weekends as compared to the weekdays. From the data obtained, calculation of carbon footprint for water consumptions was performed using equation (1). The results are then tabulated in Figure 7.

Carbon footprint (kg CO_2e) = Activity data (AD) * Emission factor (EF) (1)

Emission factors were used to indicate the total amount of CO_2 emissions that emitted for an activity data. This emission factors may be determined by direct measurement of processes or by publicly available data from Defra and DECC (Hill, 2011). The emission factors for water consumption activity data is 0.344 kg CO_2/ m^3.

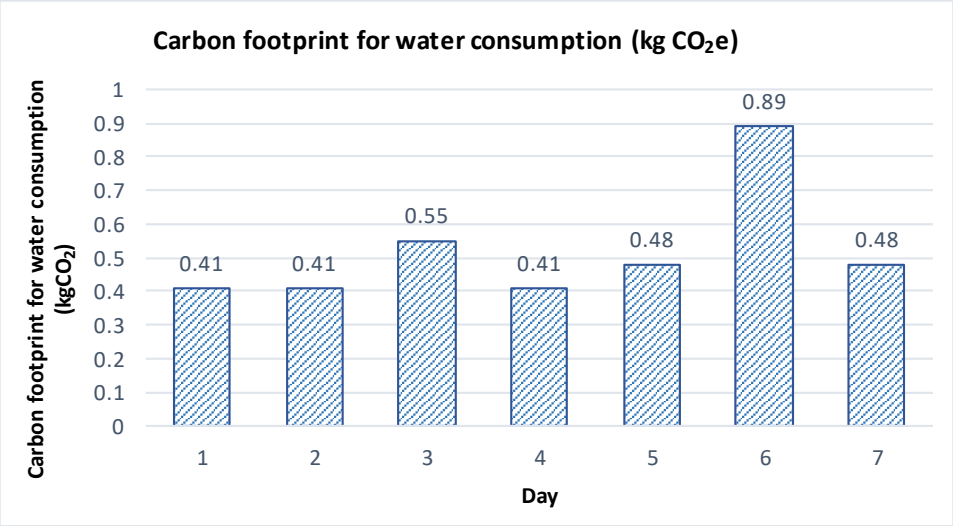

Figure 7: Carbon footprint emissions for water consumptions in Thai food restaurants, ($kgCO_2e$).

Based on the calculation for carbon footprint, the largest contributor to total carbon emissions in this study was on Friday. On this day, it consumed up to 2.6 m^3 of water consumption and emitted up to 0.89 kg CO_2 which is 24.52% of the total emissions. Next, the second largest contributor to total carbon dioxide emissions was on Tuesday, accounting for 15.15 % of total emissions. Restaurants operation had emitted 0.55 kg CO_2 during Tuesday and it is second highest to emit carbon dioxide could be due to the often usage of water consumption during the operation hour. The finding also indicate the total carbon dioxide emission on Sunday and Monday both emitted 11.259 % of total carbon dioxide emissions.

The restaurants industry uses a huge amount of water. Findings from observations and interviews owner of the restaurants revealed the most water-demanding processes occurring in the kitchens were from food preparation and dish washing. The water consumption derived in Thai food restaurants inevitably from washing of food ingredients, the cooking processes, washing up of utensils and

cleaning of the kitchen after operation hours. In addition, water plays major role in cleaning both for preparing the appropriate dilutions of detergents, sanitizers and disinfectants and also for rinsing off the cleaning chemicals. Toilets and hand washing stations also need significant amount of water. In brief, the increasing in volume of water consumption during weekends were determined by the number of customers in Thai food restaurants. Given the higher number of patrons on weekends, this appears to be legitimate reason on water usage was significantly higher on weekends compared to weekdays.

4.0 Conclusion

Food waste generated from the food service sectors recognized to give a huge impact on environment. Environmental assessment on daily operations of Thai food restaurant was evaluated and their impact to the environment has been successfully conducted in this study. From the results obtained, two main factors contributed to the most of food waste generation in the restaurants were from preparation and consumer stage. The findings presented the customers' plate waste contributed to most of the food waste which is 11.29 % in total waste on daily operations of Thai food restaurants. Preparation loss attributed only 6.88 % of total food waste on daily operations, 4.41% less than food waste generated from customer stage. Besides, the findings also revealed the most food waste produced on daily operations were on weekends.

The daily average for electricity and water consumptions were recorded to determine the total carbon footprint emissions. Since electricity is dominant type of energy consumption in Thai food restaurants, thus it created huge number of carbon dioxide emission to the atmosphere. The result on Saturday shows the highest emission of carbon dioxide that accounted 104.6 kWh of electricity consumption and emitted up to 11.42 kg CO_2 which is 19.83% of the total emissions. Meanwhile, the total carbon footprint for water consumption revealed the highest usage of water was on weekend (Friday). On this day, it consumed up to 2.6 m^3 of water consumption and emitted up to 0.89 kg CO_2 which is 24.52% of the total emissions.

From the findings acquired in this study, the daily operations within Thai food restaurants had shown on weekends contributed to the most of food waste generated compared to weekdays. Not only that, the total carbon emissions for electricity and water consumption also shown the greatest usage on weekends. In brief, the greater

number of patrons during weekends influenced the food waste issues derived within restaurants. When food was wasted, the energy and water use during food service operation hours also wasted thus leading to the release of total carbon emissions within the atmosphere that can cause harm to the environment. In response to this problems, reduction of electricity consumption could stabilize the generation of CO_2 in the atmosphere.

Reducing the input consumption of energy, improving efficiency used, and minimizing CO_2 emissions that have negative impacts on environmental health is the key in achieving balance between the economic development, energy and environment. The measure such as improving the energy and water use and food waste from restaurants' operation can ensure operating emissions is lower and more efficient. Besides, this study provided new empirical evidence to highlight the significant opportunity and scope for food waste reduction in the restaurants. By identifying the major causes of food waste, strategies for food waste prevention can be developed.

Further research is required to expand on this study's findings in different contexts within the food service sectors. The types of food waste generated within category losses should be included in future study, in order to obtain more reliable results regarding total food waste in restaurants. Not only that, the water footprint emissions can also calculated by categorizing the food waste into their specific types. The results obtained from this study was not to provide a detailed image of the total food waste produced in restaurants, but rather to provide opportunities for testing how these variables affect the generation of food waste.

5.0 REFERENCES

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6.0 APPENDICES

Appendix I

CHECKLIST FOR WASTE AUDIT

Type of food establishment: ……

Name of food establishment: ……Date of Audit: ……..

Part A: Administrative Data	
Operation hours:	
Number of staffs	
Estimated daily number of customers:	
Is on-site waste composting available?	Yes ☐ No ☐
Number of Daily Single Use Plastic	Plastic bag: ☐ Plastic containers ☐

Part B: Daily Electricity and Water Consumption

A) Daily electricity consumption

Day	**Initial meter reading (A) (kWh)**	**Upon closure meter reading (B) (kWh)**	**Actual consumption (B-A) (kWh)**
Day 1			
Day 2			
Day 3			
Day 4			
Day 5			
Day 6			
Day 7			
Total Weekly Electricity Consumption			

B) Daily water consumption

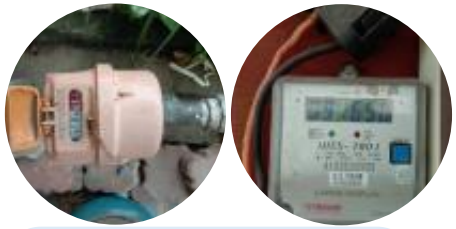
Day	**Initial meter reading (A) (litres)**	**Upon closure meter reading (B) (litres)**	**Actual consumption (B-A) (litres)**
Day 1			
Day 2			
Day 3			
Day 4			
Day 5			
Day 6			
Day 7			
Total Weekly Water Consumption			

Part B: Onsite Food Waste Audit Data								
Losses Category	**Day/kg**							**Total Weight (week)/kg**
	1	2	3	4	5	6	7	
Preparation Loss								
Serving Loss								
Customer's Plate Waste								

Appendix II

METHODOLOGY FLOWCHART FOR ONSITE WASTE AUDIT AT THAI FOOD RESTAURANTS

Interview the owner of restaurants for administrative data.



Recording the electricity and water consumption reading from meters prior operation hours.

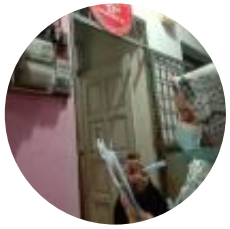
Onsite observation on food waste generation.

BEFORE AND DURING OPERATION HOUR

Calibration of weighing scale

Weighing food waste from the preparation food

Weighing food waste from patrons' plate



Recording the electricity and water consumption reading from meters after operation hours.

AFTER OPERATION HOUR