

THE COVID-19 PANDEMIC OUTCOMES ON FOOD WASTE AND CARBON FOOTPRINT OF CAFÉS IN BANDAR BARU BANGI AND SUNGAI PETANI, MALAYSIA

Mohd Iszairi NA¹, Zulkifli AA¹, Zulkifli S², Kabir Ahmad I³, Vargas RQ⁴ and Shafie FA¹.

¹Faculty of Health Sciences, Centre for Environmental Health and Safety Studies, Universiti Teknologi MARA (UiTM), Puncak Alam Campus, Selangor, Malaysia

²Institute of Pathology, Laboratory and Forensic Medicine (I-PPerForM), Universiti Teknologi MARA (UiTM), Sungai Buloh 47000, Selangor, Malaysia

³Department of Civil Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia (UKM), Bangi 43600, Selangor, Malaysia

⁴School of Industrial Engineering, Universidad de Costa Rica, San José, Costa Rica

Correspondence:

Farah Ayuni Shafie,
Faculty of Health Sciences,
Centre for Environmental Health and Safety Studies,
Universiti Teknologi MARA (UiTM),
Puncak Alam Campus, Selangor,
Malaysia
Email: farahayuni@uitm.edu.my

Abstract

Cafés, a subcategory of the foodservice industry, are popular as a place to eat and meet with others, among Malaysians and the world population. Their operation partly contributes to food waste and carbon footprint. However, the volume of these parameters fluctuated throughout the COVID-19 pandemic. Further, there is a need to diversify the food waste data of foodservice establishments in Malaysia, across different regions and cultures. Therefore, we conducted an environmental assessment of ten cafés in two of Malaysia's cafe hot spots, Sungai Petani and Bandar Baru Bangi, to determine their food waste (preparation loss and plate loss) and carbon footprint generation in a week when the COVID-19 restrictions were relaxed. Data on carbon footprint were collected by reading the electricity and water meters and calculated using emission factors. Sungai Petani generated substantially more food waste (77.68 % in total, equivalent to 93.04 kg) than Bandar Baru Bangi (22.32 %, equivalent to 26.73 kg), as revealed by material flow and descriptive analyses. Similarly, the carbon footprint from water consumption in Sungai Petani was 1.03 kgCO₂e, generated from 3m³ water consumption, whereas Bandar Baru Bangi produced 0.82 kgCO₂e of carbon footprint from 2.39 m³ water consumed, both districts on a Sunday. Contrarily, the carbon footprint related to the electricity usage in both locations was comparable. The largest amount of carbon footprint produced in Sungai Petani was on Sunday, while Saturday showed the highest carbon footprint in Bandar Baru Bangi. These findings will help the future redirection of Malaysia cafés' management towards more sustainable practices, which can be enhanced with the help of information on customer footfall.

Keywords: Food Wastage, Resources Consumption, Carbon Release, COVID-19

Introduction

The foodservice industry is one of the significant contributors to the rising quantity of food waste worldwide (1). Some examples of food services are restaurants, fast food chains, cafés, cafeterias, canteens, dining halls, and event catering (2). Pirani and Arafat (3) mentioned that foodservice is the sector from which food waste is most generated other than households. Nowadays, cafés are well-known among consumers as they provide a relaxed social space (4), and are considered trendy as consumers' recommendations spread quickly, especially through social

media. An increase in cafés visitation in Malaysia has been observed since 2007 (5), which translates to an increase in waste production. Cafés mainly serve coffees, non-alcoholic beverages, light meals as well as baked goods, with a facility to consume at the premise or takeaway. Waste in cafés is produced not only during the food preparation process and customers' plate leftovers but also from takeaway cups and packaging and customers' over-purchasing behaviour (6, 7). Essentially, cafés operations which consume a significant amount of electricity and water and the coffee itself produce carbon footprint (8, 9). Meanwhile, oversized

servings, inflexible management of cafés, and varied menus are some of the components contributing to food waste production in this type of foodservice category (10).

Food waste is a part of food loss which refers to the food that has been disposed of but is still safe and nutritious for human consumption and most likely will end up in a landfill (11). It is estimated that more than half of the solid waste disposed at landfills in Malaysia was food, based on Solid Waste Management and Public Cleansing Corporation (12). According to the Food and Agriculture Organisation of the United Nations, 1.3 billion tonnes of food are wasted globally every year (13), and more than 1.6 billion people could be fed with this wasted food. However, only 40% of the food waste can be considered legitimate food loss, such as fruit skins and bones, while the remaining 60% is food that has been wasted. Moreover, it has been shown that around 8% of all greenhouse gas (GHG) emissions globally are caused by wasted food (14). In one survey conducted by Qi and Roe (15), about 42% of the respondents felt that throwing away food is a waste of money, whereas around 58% agreed that wasting food could harm the environment. In addition, our recent data showed that the attitude and behaviour of foodservice operators are independent of their high knowledge of the factors contributing to food waste generation (16). These observations mean that a part of the human population is aware of the consequences of food waste, but most have not taken action to reduce it.

Our previous data on food waste generation in foodservice establishments have covered casual dining restaurants, cafeterias and Thai food restaurants from Kuala Lumpur, Kelantan and Melaka (17, 18). Meanwhile, this food waste information is yet to be reported in Selangor and Kedah, two Malaysian states in two different regions with different cultures, which was investigated in this study. Sungai Petani and Bandar Baru Bangi were selected based on their strategic locations, making them two of the café hot spots in Malaysia. Bandar Baru Bangi is famous for its eateries as new shop lots were developed around the township with various types of food such as Malay cuisine, Western food and more. Meanwhile, Sungai Petani is strategically located between North of Penang and South of Kedah, therefore becoming the centre of attraction that drives the establishment of cafés in Sungai Petani. While conducting this study, the foodservice industry faced unprecedented obstacles due to the COVID-19 pandemic (19). Nonetheless, food waste was still a problem since customers bought takeaways or used the food delivery service instead (20). According to a food waste report by Rabobank (21), Australian households were spending more on food delivery services, and nearly 13% of their groceries were wasted. However, this figure could vary between countries. Regardless, one of the major causes of food waste is consumer impulse buying, where one meta-analysis revealed that 62% of in-store purchases were made on the spur of the moment and that online shoppers were more prone to impulse purchases (22). As consumers were unable to shop normally, they tended to spend more time buying online, which caused food purchases made online

to increase significantly. However, customers' demands varied and were unpredictable throughout the COVID-19 pandemic; hence overproduction of food was common at that time (20).

Although studies have shown changes in food waste behaviours of households and specific subsets of the society, such as young people, during the pandemic (23-27), knowledge about food waste and carbon footprint generation from cafés especially during the global recovery from the COVID-19 lockdowns is still scarce. Therefore, we investigated how cafés from different locations in Malaysia differed in their production of food waste, consumption of electricity and water, as well as their GHG emissions after the relaxation of COVID-19 restrictions. Wasted food was traced using the Material Flow Analysis (MFA), according to their categories, to aid these cafés in developing ways to reduce avoidable food waste. The daily electricity and water usage were also recorded to determine the carbon footprint of these cafés so that appropriate measures can be taken to minimise the release of GHGs.

Materials and Methods

The general study design is illustrated in Figure 1. The data collection phases included preparation, implementation, waste collection and data analysis. Figure 2 depicts the methodology flow for assessing the daily operations of cafés in Bandar Baru Bangi and Sungai Petani. Details on the study site, such as operation hours, as well as the methods used for data analysis, are shown in Figure 2.

Preparation

Phase one was the preparation phase which involved the preparation of a well-designed checklist and the selection of five different cafés in Bandar Baru Bangi, Selangor and another five in Sungai Petani, Kedah. The checklist included the number of staff, operation hours, method of waste disposal, electricity, and water consumption. The ten cafés were chosen based on the study selection criteria, such as the location, operation hours (10 am to 10 pm) and the average number of customers (more than 30 customers daily).

Implementation

Phase two, the implementation phase, involved waste audits, including the determination of the types and quantities of food items in the system, collecting data on the carbon and water footprint, as well as observing the factors that contribute to these parameters in the ten selected cafes, all conducted daily. The data collection was conducted in Bandar Baru Bangi and Sungai Petani for a week. As per Silvennoinen et al. (28), one week is sufficient to observe the daily variance in the menu. Before the cafes' operations began each day, the initial readings of electricity and water consumption were recorded to obtain the carbon footprint data. The final electricity and water consumption readings were then recorded at the end of the day.

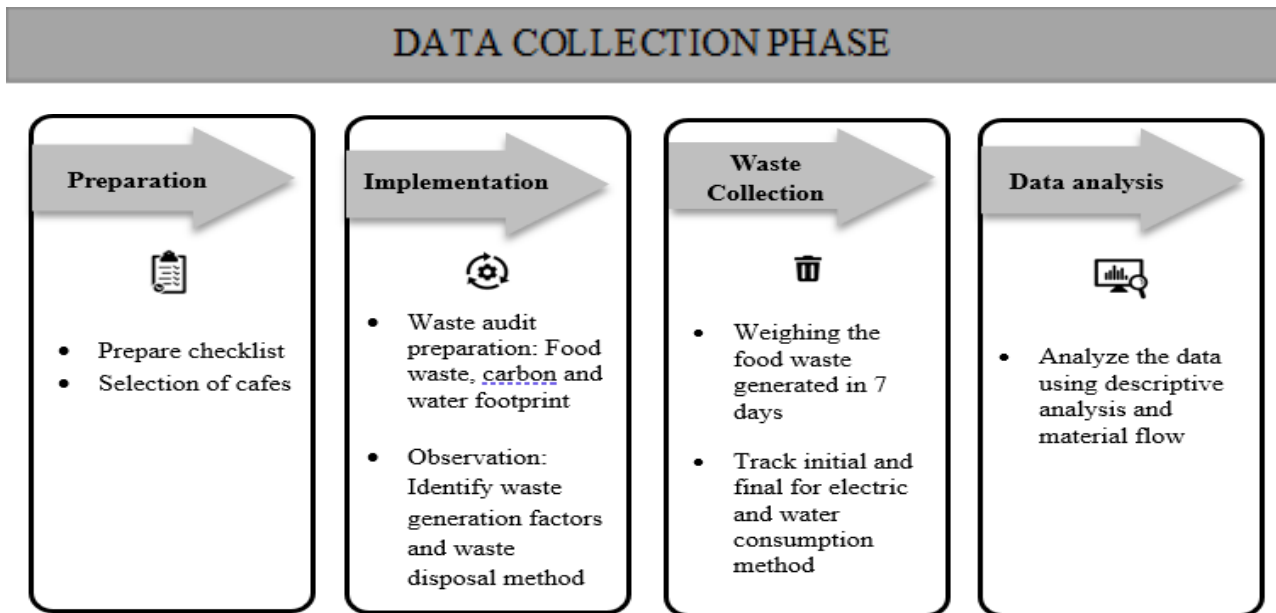


Figure 1: Overview of the study flow from the preparation stage to data analysis.

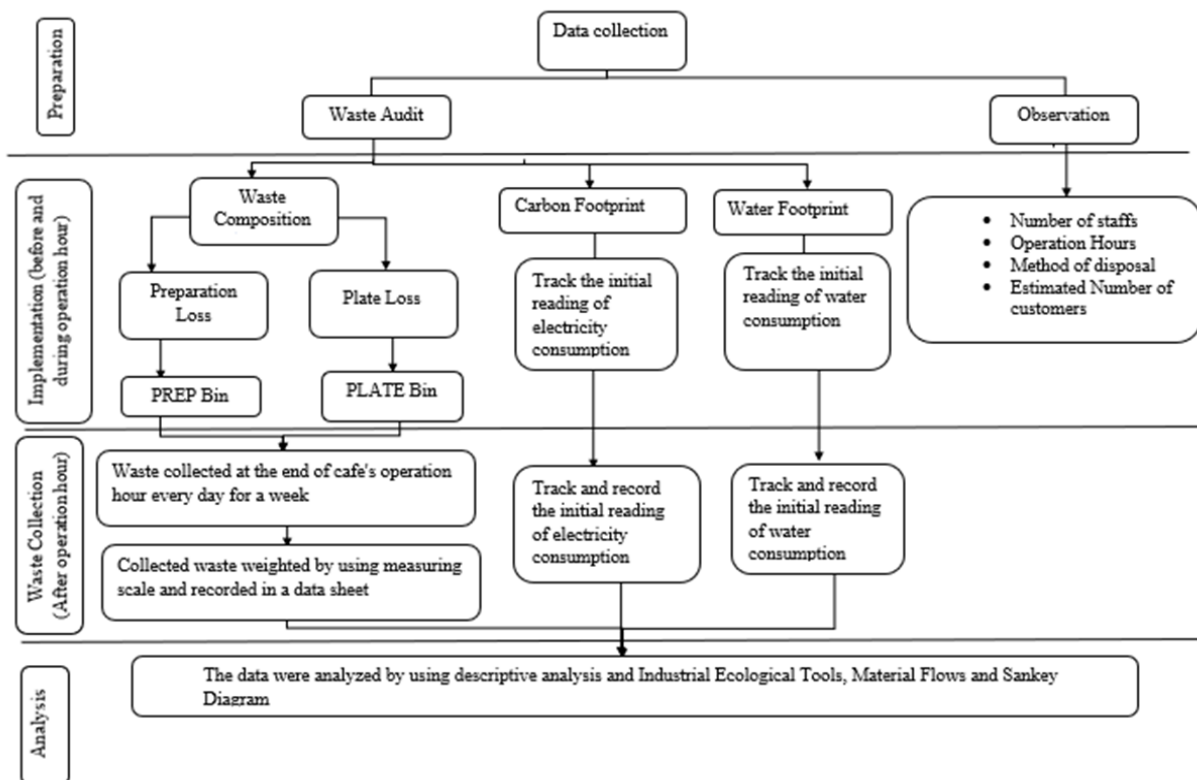


Figure 2: Research design framework from data collection to analysis. PREP is preparation loss; PLATE means plate waste.

Waste collection

In general, losses are classified into four categories such as storage losses (STOR), preparation losses (PREP), serving losses (SERV) and plate waste (PLATE) (29). However, this study focused on three types of losses only, which were:

- i. PREP loss: Food preparation and cooking losses (mainly fruit and vegetable peel, spoiled food, or fallen food) were collected throughout the preparation process.
- ii. SERV loss: Food remains from the buffet and serving bowls at the counter were collected during and after operation hours.

- iii. PLATE waste: The leftover food on the patrons' plates was collected after closing.

To collect food waste generated, three labelled bins were prepared for each café according to their loss categories, preparation loss, serving loss and plate loss. The waste collection phase took place after the cafes' operating hours. A weighing scale was used to weigh the food waste from the PREP, SERV and PLATE losses.

Data analysis

The last phase was analysing the data, which included data interpretation as well. This study utilised the material flow analysis generated using SankeyMATIC (BETA) software to visualise the flow of the food waste produced and identify which loss category produced the largest amount of waste. One previous study showed that MFA is the most effective instrument for studying and evaluating the input and output of waste created for the aim of identifying food waste management (30). Apart from that, we also used descriptive analysis to look into the data pattern of food waste production throughout the week.

To determine carbon emissions from an activity or process, two key factors are required, as shown in equation (1, 31). The first one is activity data (AD) depicting the quantification process, which has its allocated unit of measurement. For example, electricity expenditure uses the unit kilowatt-hour (kWh), while water consumption employs the unit m³. The other crucial parameter is the emission factor (EF). This parameter indicates the mass of greenhouse gases emitted per unit of activity data (kg of CO₂e, where CO₂e is a carbon dioxide equivalent). The emission factors used for the electricity and water consumption in this study were 0.10919 kgCO₂e / kWh and 0.344 kgCO₂e / cubic metre, respectively. These emission factors were recently used by Malek and Kumarasan (31), who carried out a carbon footprint assessment at a local university, Universiti Tenaga Nasional, in 2019.

Carbon footprint (kgCO₂e) = Activity Data (AD) * Emission Factor (EF) Eq (1)

Results and Discussion

Descriptive and material flow analyses showed that Sungai Petani generated significantly higher food waste than Bandar Baru Bangi

There were only two types of loss reported in this study; PREP loss and PLATE loss, since no food was thrown under the SERV loss category during the food waste audit at the ten selected cafes for both Sungai Petani and Bandar Baru Bangi. Table 1 demonstrates that the total mean of PREP loss in Sungai Petani is four times higher than that in Bandar Baru Bangi, whereby cafés in Sungai Petani recorded a total of 51.86 kg of PREP loss in a week, while cafés in Bandar Baru Bangi showed an amount of 13.28 kg of PREP loss per week. A similar trend was observed for PLATE loss, in which the total mean of PLATE loss weekly in Sungai Petani cafés tripled the amount of Bandar Baru Bangi cafés (41.18 kg and 13.45 kg, respectively) (Table 2). In addition, the highest total daily amount of PREP and PLATE losses were generated on Sunday for both study locations (15.37 kg for PREP loss and 11.09 kg for PLATE loss). In contrast, Thursday was the day with the lowest total daily amount of PREP (6.33 kg) and PLATE (6.08 kg) losses when cafés from both Sungai Petani and Bandar Baru Bangi were combined. However, the lowest daily weight of PLATE loss from cafes in Bandar Baru Bangi was generated on Monday (1.34 kg), and the highest was on Saturday (3.43 kg), which differed from the total daily mean weight for PLATE loss for both locations, in terms of the day of the week (Table 2).

Consistent with the descriptive analysis, our material flow analysis (MFA) demonstrated that cafés in Sungai Petani generate considerably more food waste than those in Bandar Baru Bangi, accounting for more than 77% of the total food waste produced (Figure 3). For cafés in Bandar Baru Bangi, the amount of waste for PREP and SERV losses was comparable (11.09% and 11.23%, respectively). It was not the same case for Sungai Petani cafés, in which the percentage of PREP loss was 1.3-fold higher than PLATE loss (43.30% versus 34.38%).

Table 1: Daily mean of food waste generated from PREP loss for cafés in Sungai Petani and Bandar Baru Bangi

PREP Loss at cafés in/on	Average weight per day (kg/day)							Total average weight (kg/week)
	Day 1 (Mon)	Day 2 (Tue)	Day 3 (Wed)	Day 4 (Thur)	Day 5 (Fri)	Day 6 (Sat)	Day 7 (Sun)	
Sungai Petani	10.18	5.72	5.30	5.40	5.66	7.22	12.38	51.86
Bandar Baru Bangi	1.54	2.99	1.67	0.93	1.74	2.96	2.99	13.28
TOTAL (kg/day)	11.72	8.71	6.97	6.33	7.40	10.18	15.37	65.14

Table 2: Daily average of food waste generated from PLATE loss for cafés in Sungai Petani and Bandar Baru Bangi

PLATE Loss at cafés in/on	Average weight per day (kg/day)							Total weight (kg/week)
	Day 1 (Mon)	Day 2 (Tue)	Day 3 (Wed)	Day 4 (Thur)	Day 5 (Fri)	Day 6 (Sat)	Day 7 (Sun)	
Sungai Petani Cafe	7.96	5.08	4.90	3.60	4.56	6.08	9.0	41.18
Bandar Baru Bangi Cafe	1.34	2.03	1.78	2.48	1.64	3.43	2.09	13.45
TOTAL (kg/day)	9.3	7.11	6.68	6.08	6.20	9.51	11.09	54.63

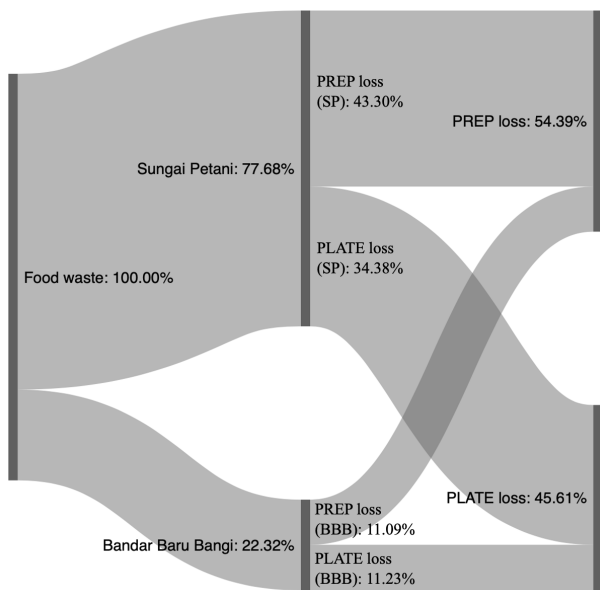


Figure 3: Sankey diagram of the material flow analysis for different food loss categories at cafes in Sungai Petani and Bandar Baru Bangi. The thickness of each link represents the flow magnitude from the total food waste generated to cafés in each study location to the loss categories. SP stands for Sungai Petani, while BBB stands for Bandar Baru Bangi.

Generally, cafés in Sungai Petani generated significantly more food waste than Bandar Baru Bangi, as shown by our material flow and descriptive analyses. There were several reasons for this. Sungai Petani cafés had a broad range of menus compared to Bandar Baru Bangi cafes. The other reason was that Bandar Baru Bangi cafes’ waste management effectively reduced the loss in their food preparation. More food on the menu may increase food preparation volume, consequently raising waste generation as well (32). Meanwhile, good waste management in food preparation, such as keeping a stock inventory and not over-buying stock, will minimise PREP loss volume in this stage (33). A qualitative analysis conducted by Diekmann & Germelmann (34) identified that overproduction due to problems or mistakes in planning demand and portion size is the major factor in PREP loss, which is avoidable. On the other hand, a survey conducted by Waste and

Resources Action Programme UK (35) suggested that the main reasons for PLATE loss production were because the food portions were too large for the customers, apart from their eating behaviour.

Other than that, we observed that there were more people who dined in at Sungai Petani cafes, while the walk-in traffic for cafes around Bandar Baru Bangi was lower. This was because the Bandar Baru Bangi population was more cautious about dining out due to the spike in daily COVID-19 (36, 37). During the pandemic, customers usually do take-aways or order online food delivery as they are the easiest options without being in close contact with other people. Paradoxically, both cafes’ locations produced the highest PREP loss on Sunday, which is the weekend for Bandar Baru Bangi but a working day for Sungai Petani. Plate loss was also the highest on weekends for both Sungai Petani and Bandar Baru Bangi cafes. The reasonable explanation for these findings was that customer visits are more frequent on weekends as they are the most suitable time to wind down at the cafés after a hectic week. Although Sunday is not a weekend for the states in Kedah, the foot traffic for Sungai Petani cafés was a mix of the people from the district itself and from Penang as well, which have their day off on Sunday, based on our brief interviews with the cafes’ owners.

Regardless, the limitation of the current study is that customer footfall per day was not recorded, hence the amount of food waste, energy and water consumption, as well as their associated carbon footprints for each customer, is unknown. This information is important in determining the suitable sustainable waste management measures that can be taken to combat food waste in cafés especially in Selangor and Kedah.

Carbon footprint from Sungai Petani cafés was comparable to those in Bandar Baru Bangi, concomitant with their daily electricity consumption

Electricity is not just a basic amenity, but it is also one of the primary sources of global warming (38). Hence, GHG emissions, also known as carbon footprint, were assessed in all ten cafés in Sungai Petani and Bandar Baru Bangi. We observed that the daily average electricity

consumption of cafés in Bandar Baru Bangi was the highest on Saturday (112.8 kWh), followed by Thursday (109 kWh) (Figure 4). Meanwhile, the lowest daily average electricity consumption for Bandar Baru Bangi cafés was on Friday, which was 84.2 kWh. As for cafes in Sungai Petani, the electricity consumption was the lowest on Tuesday with a daily average of 91.2 kWh, and the highest on Sunday with a daily average of 128.2kWh for carbon footprint.

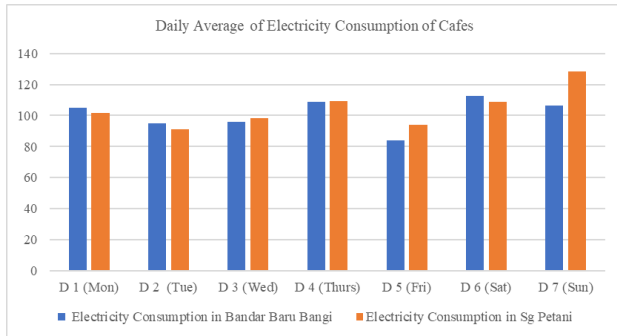


Figure 4: Daily average electricity consumed by cafés in Bandar Baru Bangi and Sungai Petani in a week.

In line with the electricity consumption data, our carbon footprint analysis showed that the day with the greatest GHG emissions in Bandar Baru Bangi was on Saturday, with an average of 12.32 kgCO₂e, while the lowest carbon emitted in this district was on Friday, with an average of 9.19 kgCO₂e (Figure 5). In contrast, Sunday contributed the highest amount of GHGs for Sungai Petani, which was 14 kgCO₂e, while Tuesday showed the lowest amount of carbon footprint in this location, which was 10 kgCO₂e. Overall, both the lowest and largest carbon footprint from Sungai Petani and Bandar Baru Bangi cafés were similar.

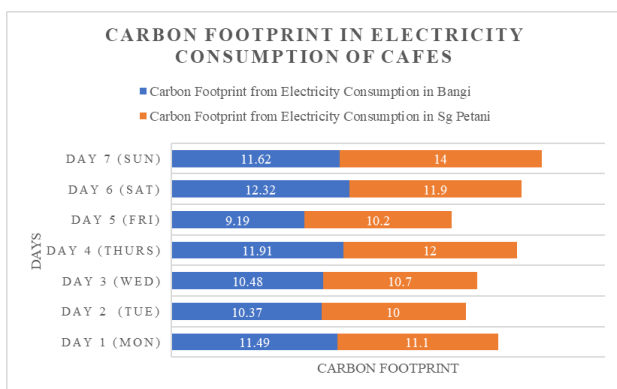


Figure 5: Carbon footprint from electricity consumption of cafés in Bandar Baru Bangi and Sungai Petani.

The comparable electricity consumption associated-carbon footprint of Bandar Baru Bangi cafés and Sungai Petani cafés may suggest that the cafés in Bandar Baru

Bangi consumed more energy than they should. From our observation, the selected cafes usually have three to four air conditioners which ramped up the electricity usage. This, in addition to other electrical appliances usage, may have contributed to the cafés’ large carbon footprint. Besides, the placement of ovens and the fridges, which was not ideal and poor ventilation in the kitchens may also increase the workload for the fridges to stay cool. Other factors that could influence the energy usage per unit of floor area are quantity of meals served, operation hours, types of foodservice, menu items number and complexity, and productivity standards, which vary extremely among foodservice facilities (39). Several strategies that can be done to conserve electricity in the cafés are by having an efficient kitchen layout, using energy-efficient equipment and lighting, reducing the kitchen ambient temperature, performing equipment maintenance and practising good kitchen protocols (40).

Weekly carbon footprint related to the water consumption in Sungai Petani cafés was higher compared to Bandar Baru Bangi cafés

The world has been facing a water crisis from the year 2000 until now (41). Moreover, water usage contributes to GHG emissions from its treatment, pumping, abstracting and other activities which consume energy (42). Therefore, water usage and its carbon footprint from cafes in Sungai Petani and Bandar Baru Bangi were examined to encourage water sustainability practices in this type of foodservice. It was shown that Sunday and Thursday had the highest water consumption for the daily operations of the five cafés in Bandar Baru Bangi, which recorded an average of 2.39 m³ and 2.13 m³, respectively (Figure 6). On the other hand, the daily water consumption in Sungai Petani showed that weekends consumed the most water per day compared to other days, whereby Saturday contributed 2.5 m³ of water on average, and Sunday 3 m³.

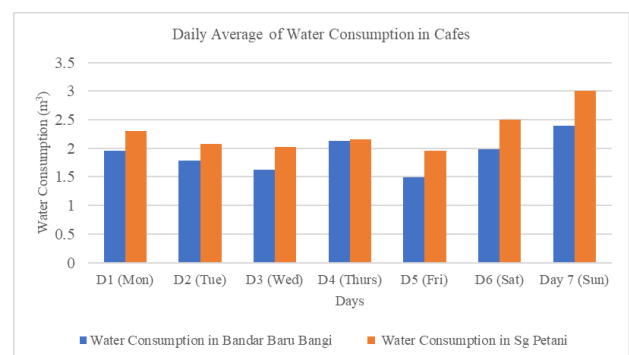


Figure 6: Daily average water usage at cafés in Bandar Baru Bangi and Sungai Petani in a week.

As for the carbon footprint data associated with the daily water consumption of the cafes, we observed the same trend for both study locations, in which GHG emissions

declined at the beginning (Monday; 0.8 kgCO₂e in Sungai Petani versus 0.67 kgCO₂e in Bandar Baru Bangi) until the middle of the week (Wednesday; 0.7 kgCO₂e in Sungai Petani versus 0.56 kgCO₂e in Bandar Baru Bangi), but dramatically inclined when headed into the weekend (Friday till Sunday) (Figure 7). The amount of carbon emissions in Bandar Baru Bangi and Sungai Petani peaked on Sunday, with an average of 0.82 kgCO₂e and 1.03 kgCO₂e, respectively. Meanwhile, the lowest amount of carbon footprint for both districts were observed on Friday, with Sungai Petani emitting 0.67 kgCO₂e of GHGs, while Bandar Baru Bangi released 0.51 kgCO₂e of GHGs.

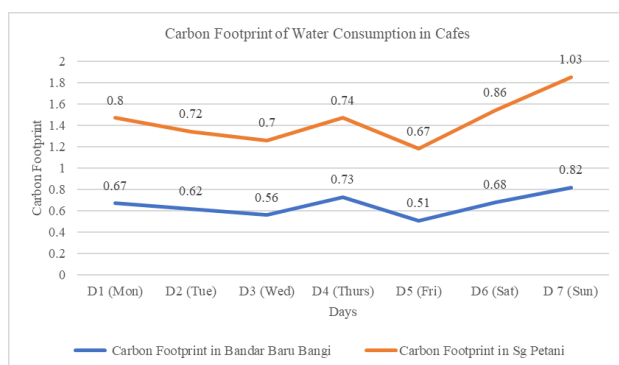


Figure 7: Carbon emissions related to the daily water usage at cafés in Bandar Baru Bangi and Sungai Petani.

Our carbon footprint data resulting from water usage activities corresponded with the food waste results, in which Sungai Petani cafés released more carbon than Bandar Baru Bangi cafés. In the daily operation of cafés, water is undoubtedly crucial to enable the production of food and beverages on the menu. Moreover, all the selected cafes in this study offered different types of coffee drinks on their menus. According to the Specialty Coffee Association of America, it was documented that wastewater produced during coffee milling can pollute up to 40 times more water than typical urban sewage waste (43). Water is the most essential ingredient in coffee brewing, in which about 98.5% of a drip coffee and around 90% of an espresso shot is comprised of water (44). It is utilised not just for brewing but also for dishwashing, cleaning the food preparation area, ice manufacturing, restrooms, and hand washing. This means that water is consumed during operation hours, as well as before and after. Water supply and wastewater treatment systems demand energy inputs throughout their whole processes (45), in which an increase in water consumption will translate to an increase in energy levels. With the rates of carbon emissions linked to the cafés' water usage, as well as from other sources, GHG emissions will become a global burden to the environment and public health in the future, as estimated in a number of studies (46-49). Some initiatives that the cafés management can do are by checking for leaks and drips, thawing food overnight

in the fridge, using water efficient appliances, and serving guests efficiently.

Conclusion

Food waste and carbon footprint of a café after easing COVID-19 lockdown and restriction measures may depend on the number of patrons, which relies upon the consumers' dining-out behaviour, the number of local COVID-19 cases, the location of the café as well as the population density itself (50, 51). Regardless, this information was solely based on observations and data were not recorded properly hence further analyses, such as qualitative and quantitative, cannot be conducted. The findings of this study will provide a platform for better food waste management and GHG reduction in this foodservice sector in Malaysia. This is because most Malaysian cafés do not have efficient waste and carbon footprint management practices, as revealed in our environmental evaluation of these cafés. In addition, although it has been shown that consumers are aware of the adverse impacts of food waste, deficiency in proper law and legislation makes customers and cafés management take the environmental consequences lightly (52-54). Therefore, the Malaysian government, citizens and NGOs (non-global organisations) should all work together towards a more sustainable environment by abiding by the to-be-established government policy and enforcement, as well as by introducing environmental education to all levels of learning institutions (55). Importantly, cafés management should take the first step in sustainable practices by engaging and understanding the advantages of food waste reduction, which may help businesses to accomplish sustainability goals and, at the same time, improve the foodservice industries' sales. Nonetheless, the future directions of this study shall include the comparisons between before and during the pandemic for the food waste and carbon footprint generation, the demographic and the size of the population, as well as more participation from the other cafés.

Competing interests

The authors declare that they have no competing interests.

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