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Carbon Footprint Analysis Of Food Waste From Restaurants In Bogor City

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ABSTRACT
Restaurants are Indonesia's biggest producers of trash since they provide meals every day, which contributes to a rise in food waste. The purpose of this study was to examine the quantity and kind of food waste produced by large-scale restaurants in Bogor City, as well as the carbon footprint that this garbage leaves behind. Additional evaluation of the impact of food waste output and composition on CO2 emissions was done in this study. This study separates edible food waste from non-edible food waste using a sample technique based on Waste Composition Analysis (WCA). The emission factor is calculated in order to determine the carbon footprint. According to the study's findings, which included 120 samples from three restaurants in Bogor City, the average daily production of food waste from the simple payakumbuh, pagi sore, and bumi aki restaurants in Bogor City was 4,239.70 g/plate, and the average daily generation of edible food waste was 12,026.70 g/org. It is made up of 14.3% foods high in protein, 40.1% fruits and vegetables, and 45.6% foods high in carbohydrates. Produce (40.1%): fruits and vegetables; foods high in protein (14.3%). Pagi Sore generates the least amount of edible food waste (988 g/org/day), whereas Payakumbuh restaurant produces the most (26,834 g/org/day).

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INTRODUCTION

In the age of globalization, environmental problems are just becoming worse and creating a lot of new ones. The growing amount of garbage is one of the environmental difficulties. One of the most prevalent issues in Indonesia, particularly in large cities, is waste. There are greater waste issues as a result of the large-scale population movement to cities. The population has a big impact on the garbage the community produces on a daily basis. The issue of land disposal requirements, high waste management costs, and environmental expenses resulting from trash will all be impacted by the growing volume of garbage (Fandeli, 2020). Food waste is one kind of trash that the community produces frequently.

Food waste is defined as food loss resulting from a drop in food weight or quality at any point in the food supply chain, according to the Food Agriculture Organization of the United

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Nations (FAO) (FAO, 2011). Food waste is defined by the FAO as food loss resulting from a variety of variables, including production and consumption levels (FAO, 2014). The phrase "food waste" refers to the whole food supply chain, which involves food production, post-harvest operations, storage, processing, and final consumers. The term "food waste chain" refers to food wasted at the ultimate customer or at the end of the food supply chain. The world's population would experience global food shortage in 2050, with 9.1 million people not having enough food to eat (Abdelradi, 2018). To feed everyone on the planet, food output must rise dramatically during the next 30 years. Food waste collected from landfills will be processed into biogas, a natural gas that has the potential to emit 21 times more CO2 than is now produced, therefore contributing to global warming (IPCC, 2007). It is well known that throwing away food waste adds to the rise in greenhouse gasses on Earth since it breaks down more quickly and releases more methane into the atmosphere than other organic material dumped in landfills (Levis & Barlaz, 2011). Food waste wasted is resource waste. Food waste results in financial losses related to the production of food, including the cost of purchasing energy, water, and other raw materials (Wulansari, 2019). As per the findings of a 2017 study published in the Food Sustainability Index report by The Economist Intelligent Unit (EIU), Indonesia is the nation that generates the second-highest amount of food waste, behind Saudi Arabia. Indonesia has the highest rate of household food waste in Southeast Asia, according to a research published by the United Nations Environment Program (UNEP) titled Food Waste Index research 2024. 14.73 million tons are expected to be produced year (Amalia & Ar, 2024). According to information gathered by the Ministry of Environment and Forestry (KLHK) from the National rubbish Management Information System (SIPSN), Indonesia generated 35.92 million tons of rubbish in 2022 (KMLH, 2022). Comparing this number to 2021, which was 29.46 million tons, there was a 21.92% rise. Food trash is the most common sort of garbage generated, accounting for 40.64% of all waste produced in the country. A single food waste facility in the West Java Province alone produces 4.89 million tons of food waste annually.

People travel to Bogor City frequently for tourism-related purposes. In the case of Bogor, where there are several restaurants, food waste is frequently linked to the issue of tourism. As a culinary establishment that serves meals every day and contributes to a rise in food waste, restaurants are among the biggest producers of trash. Food waste is the leftover food that customers do not finish and is produced by the food service industry (Silvennoinen, Heikkila, Katajajuri, & Reinikainen, 2015). Food waste and restaurants go hand in hand; wherever there are food-consuming activities, there will inevitably be consumer-generated food waste. Food waste generated by restaurants is determined by taking into account food waste that is still edible but has not been consumed by customers (Wulansari, 2019). Rice makes up the majority of food waste, accounting for 60% of the total waste weight produced by three out of every four eateries, according to study done in Babakan Village, Dramaga District, Bogor Regency. This is brought on by servings that are larger than what customers require, resulting in food waste. Restaurants and other food service companies play a significant role in food waste management since most food is thrown out during preparation or is not suitable for repurposing (serving). The food waste investigation carried out in the

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study (Wulansari, 2019) took place after dine-in cuisine was consumed by customers. In Bogor City, Payakumbuh Simple Restaurant, Pagi Sore, and Bumi Aki Restaurant are the most well-liked eateries across all social groups. This occurs as a result of the food's excellent flavor and ability to suit palates from different backgrounds. Targeting middle-class to upper-middle-class consumers, this restaurant caters to a range of socioeconomic classes. Several meal options with readily available ingredients are offered by this expansive eatery. Food consumption by the community will increase with the number of eateries. Consumption activities in today's society have evolved beyond merely sating hunger to become a way of life that may define one's identity, class, group, and other aspects of oneself. It is believed that these practices contribute to food waste in people's lives. Food waste is generated by restaurants among other sources.

Food waste happens when food is not used to its full potential, for example, when too much food is cooked or taken, leaving a large amount on the plate. Food waste management is crucial since improper management will have an influence on society's finances and ecology. Food waste management techniques are still in the development stage, current waste management system emphasizes the 3Rs (Reduce, Reuse, Recycle) to bring about a good influence on trash management. This is due to the fact that there are still a lot of financial and facility constraints on the processing of food waste. Due to a lack of knowledge about waste management, the majority of residents in Bogor City manage their trash poorly. Chemicals, resources, and fuel are consumed more as food waste increases.

From this phenomenon, researchers have made observations and asked directly to one of the staff of the three restaurants to be studied, it is true that the restaurant is often crowded with visitors where there will be an increase in visitors on weekends. it can be concluded that one of the first problem points is that there will definitely be food waste from visitors who eat directly at the restaurant. Further investigation was carried out on the quantity and makeup of food waste produced by Payakumbuh basic restaurant, Pagi Afternoon, and Bumi Aki restaurant, in light of this occurrence. This is because food waste types and client socioeconomic levels are taken into account. Furthermore, a study was carried out to investigate the carbon footprint of food waste generated by the three restaurants under investigation. Following the analysis and evaluation of the available data, suggestions for reducing and preventing losses from food waste produced by the restaurants under study can be made.

METHODS

This study employs a quantitative approach because it has well-defined components, including objectives, subjects, and concrete, detailed data sources from the outset. Additionally, the research is transparent, samples are used, and data analysis is done once all the data has been gathered (Arikunto, 2013). The link between a sample of food waste created and the carbon footprint in a certain location may be demonstrated with the use of the quantitative technique. In addition to analyzing the overall CO2 emissions from food waste in various restaurants in Bogor City, this research will also look at the waste composition of the food waste produced by the restaurants under investigation. Finally, it will

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offer suggestions for lowering food waste in the restaurants under investigation. The primary data that is collected from restaurants is food waste, namely the type of food that is left behind and the weight of each sort of food waste for a total of 40 servings at three sample restaurants in Bogor City. In order to gather information for food waste studies and restaurant carbon footprints, the next key data source is distributing questionnaires or interviewing restaurant owners. The secondary data that is sought after is information from the objective chapter of the literature that has been gathered from journals, scientific articles, website documents, and also earlier research reports on the subject—specifically, the average number of restaurant patrons and the emission factor of each type of food. The quantity of food waste produced by restaurants was the subject of data collection, which took place between early and late April over the course of about a month. Data was gathered at eateries in the Bogor City neighborhood using random location points while yet taking representative data into account. The Payakumbuh restaurant, Morning Afternoon Restaurant, and Bumi Aki restaurant were the eateries under study. Purposive sampling was the approach employed to choose the study's sample. With this sampling methodology, the population that will participate in the study is chosen by the researcher based on a certain category or judgment. For one day, food waste was sampled from three restaurants, with a sampling goal of forty servings (plates) each establishment. To ensure that the quantity of portions at every restaurant is consistent and does not influence the dependent variable, 40 portions were determined. In this work, sampling techniques such as Waste Composition Analysis (WCA) are used to separate edible food waste from non-edible food waste. This study also makes reference to SNI 19-2454-2002, which deals with operational methods for managing urban garbage. Over the course of three days, one restaurant was sampled each day. Restaurant managers who had received information on how to collect food trash helped with the collection of food waste for this study. A maximum of 40 dishes per restaurant may be sampled for this investigation. Furthermore, only food waste—excluding straws, paper, plastic, and drinks packaging—was gathered into a specific sample container. Both pearson correlation and the p-value data analysis approach were used in this study's computations to determine the correlation matrix. To examine the impact of food waste generation and kind on the overall amount of carbon produced, the p-value is utilized. If a direct association exists between the amount of food waste generated and the overall amount of carbon released by the restaurant, it may be examined using the pearson correlation.

RESULTS AND DISCUSSION

Food Waste Generation and Composition

Food waste from three restaurants was sampled for this study between April 1, 2024, and May 1, 2024, with 40 plates from each restaurant under investigation. The food waste under study was gathered into a garbage bag; no storage was carried out, thus it was sorted right away in the open area. The following table displays waste production information for the restaurants under investigation

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Table 1. Food Waste Generation from Restaurants in Bogor City

No	Rrestaurants	g/food house/day			g/plates/day		Number of plates/ day	Edible Fraction /Total Food Waste(%)	Total Waste Checked During the Day (g/day)
		Total Food Waste (g/day)	Total Edible Food Waste (g/day)	Total non Edible Food Waste (g/day)	Total Food (g/plates/ day)	Edible Food Waste (g/plates/ day)			
1	SP	3,929	26,834	12,456	7,858	5,367	40	6,830	3,929
2	PS	12,496	988	2,616	2,499	1,976	40	7,907	12,496
3	BA	1,181	8,258	3,552	2,362	1,652	40	6,992	1,181
Total		17,606	36,080	18,624	12,719	8,995	120	21,729	17,606
Rerate		5,868.70	12,026.70	6,208	4,239.70	2,998.30	40	7,243	5,868.70
Standar Deviasi		5,902	13,329	5,431	3,134	2,058	0	581	5,902

Overall, the total weight of food waste produced by all the restaurants that were surveyed is 21,729 grams. Of this total weight, food waste is naturally divided into two categories based on its eligibility: edible food waste, which makes up 36,080 grams or 69 percent of the total weight, and non-edible food waste, which makes up 18,624 grams of the total weight and is produced by inedible food parts like bones. Table 1 provides a summary of the food waste samples from the three restaurants under investigation. There are still notable distinctions between the biggest and smallest food waste producers, even if the sample procedure has been limited to 40 meals for a single restaurant. The SP (Sederhana Payakumbuh) restaurant has the most overall food waste, at 3,929 g/day. At 1,181 g of food waste per day, the BA (Bumi Aki) restaurant is the eatery with the least amount of food waste overall. In terms of total edible waste, Bumi Aki is the lowest waste maker and Payakumbuh restaurant is the most. The SP (Sederhana Payakumbuh) restaurant's high food waste rate can be attributed to the size of the piece of food supplied on a single plate, which is considerably larger than in other restaurants. This increases the likelihood of food waste occurring. Compared to other restaurants, the portions of every type of cuisine, including the jackfruit veggie menu, are sufficiently substantial at this SP (Sederhana Payakumbuh) restaurant. Based on this computation, the three restaurants under investigation had a total of 17,606g of food waste each day, or 5,868.70g on average. The average number, which is quite high when compared to the standard deviation, suggests that there is not much variation in the distribution of food waste data across all restaurants. In this study, a variety of food types were sampled in multiple restaurants. The weight of each type of food was determined by dividing it into food categories, which included fruits and vegetables, oils, carbohydrate-rich foods, and protein-rich foods. Table 2 shows the results of the sampling in grams as well as the average weight of each food category per plate.

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Tabel 2. Sampling Results of Food Waste in Weight Units

Food Category	Weight (gram/day)			Total (g/day)	Average (g/day/food house)	Standard Devitiation
	SP	PS	BA			
Carbohydrate – rich foods	638	560	423	1,621	540.33	108.84
Protein – rich foods	386,4	116	126,8	116	116	386,4
Fruits and Vegetable	1,659	312	276	2,247	749.0	788
Oil	0	0	0	0	0	0

Table 3. Average Weight of Each Food Category Per Plate

Food Category	Average Weight (gram/day)			Total (g/day)	Average (g/day/food house)	Standard Devitiation
	SP	PS	BA			
Carbohydrate – rich foods	1,276	112	846	2,234	744.67	588.58
Protein – rich foods	773	232	254	1,259	419.67	306.19
Fruits and Vegetable	3,318	624	552	4,494	1,498.00	1,576.58
Oil	0	0	0	0	0	0

Table 4. Percentage of Food Streams in Each Category

Restaurants/Food Category	Percentage of Food Streams in Each Category (%)			Category Percentage
	SP	PS	BA	
Carbohydrate – rich foods	24%	57%	51%	56%
Protein – rich foods	14%	12%	15%	26%
Fruits and Vegetable	62%	32%	33%	18%
Oil	0%	0%	0%	0%

A comparison of the food waste categories that one restaurant generates the most or the least may be seen from the data. With an average gram count of 749.0, fruits and vegetables are the food category that produces the greatest food waste. The average weight of each food type per plate is similarly consistent with this value, with fruits and vegetables having the highest value. This is because the restaurants that were studied serve rice and veggies as the primary course, with other side dishes being more optional. In the meantime, there are typically multiple varieties of fruits and vegetables offered, with cucumber and chili sauce falling within this group. There's also the fact that several of the restaurants surveyed served a large amount of veggies without asking their patrons, which meant there were a lot of leftovers. Payakumbuh restaurant was one of the eateries that carried out this practice.

Produce that is high in carbohydrates, such as fruits and vegetables, makes up the majority of food waste. Conversely, the number of foods that are high in protein is quite low, as these foods typically only come in one variety per piece. Another factor is that the food waste in question is edible, which lessens the category's weight associated with food waste

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high in protein. This is because the percentage of non-edible waste in this category is typically rather high.

Table 5. Types of Food that have the Highest Recoverable Value by Category

Category	Type	Weight of Waste Generation for Each Type of Food (gram/day)				Average (grams/plate/day)
		SP	PS	BA	TOTAL 3 RM	
Carbohydrate – rich foods	Rice	638	560	423	1621	540.33
	Potatoes	75	0	40	115	38.33
	Flour	0	0	0	0	0
	Corn	0	0	0	0	0
Protein – rich foods	Legumes	0	0	0	0	0
	Legumes	0	0	0	0	0
	Ground Stake	0	0	0	0	0
	Tofu	0	0	38	38	0,08
	Eggs	75	0	0	171	0,34
	Chicken	742	318	258	1318	439.33
	Beef	1448	48	302	1798	599.33
	Fish	974	888	678	2540	846.67
	Shrimp	54	86	0	140	46.67
Fruits and Vegetable	Bananas	0	0	0	0	0.00
	Orange	0	0	0	0	0.00
	Tomatoes	0	0	0	0	0.00
	Cabbage and Cabbage	53	0	0	53	17.67
	Onions	0	0	0	0	0.00
	Leeks	0	0	0	0	0.00
	Carrots	0	0	0	0	0.00
	String beans	0	35	0	35	11.67
	Bean sprouts	0	0	0	0	0.00
	Red chili	0	43	0	43	14.33
	Green chili	0	40	0	40	13.33
	Cucumber	0	0	0	0	0.00
	Jackfruit	796	0	56	852	284.00
	Cassava leaf	770	194	125	1089	363.00
	Coconut	0	0	0	0	0.00
	Chickpeas	40	0	0	40	13.33
	Lettuce	0	0	0	0	0.00
	Eggplant	0	0	95	95	31.67
Oil	Coconut oil	0	0	0	0	0.00
	Olive oil	0	0	0	0	0.00

From the carbohydrate-rich food category, rice has the highest amount of food waste, with 1,621 grams overall and an average of 54,033 grams per plate. This is due to the fact that rice is a staple meal for Indonesians, particularly at eateries where rice is served as the

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main course, which increases the likelihood of rice waste production. Another factor is that huge quantities of foods high in carbohydrates, such potatoes, flour, and corn, are uncommon in Bogor City eateries. Fish has the most food waste of any protein-rich food group, with 2,540 grams overall and an average of 846.67 grams per plate. The reason for this is that restaurants that provide a lot of different side dishes, such tilapia, catfish, grilled fish, snapper head, and goldfish, tend to create the most waste from their fish menu. Furthermore, a lot of the processed fish's edible parts—like the head, fish skin, and a large amount of the flesh that is challenging to remove from the bones—are not palatable to customers. In contrast, cassava leaves, with a total weight of 1,089 grams and an average of 363.0 grams per plate, lead the restaurant's fruit and vegetable category. The reason for this is that, in contrast to other vegetables that are specifically ordered, there is a greater chance that cassava leaves will go to waste because they are a required menu item that is always served when a customer orders a rice meal, regardless of whether they like it or not.

Carbon Footprint of Food Waste in Bogor City

Carbon Footprint Calculation Results

Table 6. Restaurant Carbon Footprint Calculation

Category	Types of Food	Emission Factor (g CO2 eq/g)	Total Edible Waste (g/hari)	Carbon Footprint (g CO2 eq/day)	Average Carbon Footprint per plate (g CO2 eq/plate/day)	Average Carbon Footprint (kg CO2 eq/plate/day)	Total Carbon Footprint (kg CO2 eq/plate/day)	Total Carbon Footprint Per Year (kg CO2 eq/plate/year)
Carbohydrate – rich foods	Rice	4,5	469	2.110,5	42,21	42	42	15,4
	Potatoes	0,5	0	0	0	0		
	Flour	2,5	0	0	0	0		
	Corn	1,7	0	0	0	0		
Protein – rich foods	Legumes	1	0	0	0	0	0,12	42,54
	Legumes	1,8	0	0	0	0		
	Ground Stake	0,4	0	0	0	0		
	Tofu	3,2	0	0	0	0		
	Eggs	4,7	18	84,6	1,692	2		
	Chicken	9,9	57	564,3	11,29	0,01		
	Beef	99,5	37	3.681,5	73,63	73		
	Fish	13,6	97,4	1.324,64	26,49	26		
	Shrimp	26,9	6,4	172,16	3,44	3		
Fruits and Vegetable	Bananas	0,9	0	0	0	0	0,03	11,19
	Orange	0,4	0	0	0	0		
	Tomatoes	2,1	0	0	0	0		

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Category	Types of Food	Emission Factor (g CO2 eq/g)	Total Edible Waste (g/hari)	Carbon Footprint (g CO2 eq/day)	Average Carbon Footprint per plate (g CO2 eq/plate/day)	Average Carbon Footprint (kg CO2 eq/plate/day)	Total Carbon Footprint (kg CO2 eq/plate/day)	Total Carbon Footprint Per Year (kg CO2 eq/plate/year)
	Cabbage and Cabbage	0,5	0	0	0	0		
	Onions	0,5	0	0	0	0		
	Leeks	0,5	0	0	0	0		
	Carrots	0,4	0	0	0	0		
	String beans	0,2	0	0	0	0		
	Bean sprouts	0,24	0	0	0	0		
	Red chili	4,13	0	0	0	0		
	Green chili	4,14	0	0	0	0		
	Cucumber	0,14	0	0	0	0		
	Jackfruit	0,9	0	0	0	0		
	Cassava leaf	0,27	129	34,83	0,69	7		
	Coconut	2,1	0	0	0	0		
	Chickpeas	0,44	0	0	0	0		
	Lettuce	0,27	0	0	0	0		
	Eggplant	0,09	18	1,62	32	3		
Oil	Coconut oil	7,3	0	0	0	0	0	0
	Olive oil	5,4	0	0	0	0		

It's required to create a table that compiles the carbon footprint calculations based on the four categories from the survey results for each restaurant. To make it simpler to view the data overall and to make studying each restaurant's carbon footprint easier, the computation has produced a summary table.

Table 7. Average Carbon Footprint Summary by Food Category

Food Category	Average carbon footprint per plate per year (kg CO2 eq/plate/year)			Total Emissions (kg CO2 eq/plate/year)	Average (kg CO2 eq/plate/year)	Percentage of Carbon Footprint (%)
	SP	PS	BA			
Carbohydrate – rich foods	2,096	184	139	2,419	806	2,675

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Food Category	Average carbon footprint per plate per year (kg CO2 eq/plate/year)			Total Emissions (kg CO2 eq/plate/year)	Average (kg CO2 eq/plate/year)	Percentage of Carbon Footprint (%)
	SP	PS	BA			
Protein – rich foods	12,281	4,159	2,794	19,234	6,411	5,684
Fruits and Vegetable	1,677	737	393	2,807	936	1,641
Oil	0	0	0	0	0	0
Total	16,054	5,080	3,326	24,460	8,153	10,000

According to the findings of the carbon footprint calculation summarized, the three restaurants' combined annual carbon footprint was estimated to be 24,460 kg CO2 equivalent. Furthermore, the average carbon footprint created is calculated to be 8,153 kg CO2 equivalent year. This outcome is derived from adding up the typical carbon footprint that every restaurant produces. Furthermore, dietary categories having the highest carbon footprint on average are those high in protein, generating 6,411 kg CO2 equivalent annually. Each food type in this category has a higher emission factor than those in other categories, with beef reaching a value of 99.5 kg CO2 equivalent. This might have an impact. those high in carbohydrates might weigh more than those high in protein, yet the reverse is true in terms of carbon footprint. The life cycle of cattle and the methods used in beef production are the causes of the high emission factor (Schroeder et al., 2012). It takes a lot of resources, including feed and water, to raise the weight of cattle production and livestock. In order to fulfill the demands of cattle, this results in extremely large indirect greenhouse gas emissions. When comparing cattle to other animals, such pigs and poultry, they also grow less weight.

Payakumbuh is the restaurant with the biggest carbon footprint, producing 16,054 kg of CO2 equivalent year. This is because, in comparison to other restaurants, there is a greater production of edible food waste, especially from protein-rich dishes like beef. In contrast to Pagi Sore restaurant, eateries like Bumi Aki have a lower carbon footprint value while producing a greater quantity of edible trash. Thus, it is essential to examine the ingredients in each kind of cuisine that a restaurant produces. The investigation reveals that Pagi Sore restaurant has heavier protein-rich cuisine than Bumi Aki restaurant. Furthermore, food waste in the form of fruits and vegetables, which has a significantly lower emission factor, predominates at the Bumi Aki restaurant. Bumi Aki, on the other hand, has the least carbon footprint of any restaurant, generating 3,326 kg CO2 equivalent year. The root cause remains mostly unchanged: waste is primarily composed of two types of food: foods high in carbohydrates and fruits and vegetables. The only foods high in protein at Bumi Aki restaurant are chicken and fish, which have daily weights of 42.3 g and 67.8 g, respectively.

The overall carbon footprint produced by the 10 restaurants in this research may be calculated by multiplying the total number of plates served by the average carbon footprint produced by all the restaurants.

Total Carbon Footprint = Total Average Carbon Footprint X Number of Plates

Total Carbon Footprint = 4,239.70 kg.CO2 eq / Plate / Year X 120 Plates

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Total Carbon Footprint = 50,876 kg.CO2 eq/year

Table 8. Comparison of Average Carbon Footprint with Pelita Bangsa University Environmental Engineering Research

Locations	Total Average Carbon Footprint (KgCO2eq/plate/year)	Sources
Bogor City, Indonesia	62,28	Author's Research
Makassar City, Indonesia	46,69	(Aqilah, 2022)
Ternate City, Indonesia	53,3	(Muhtar, 2021)
Banda Aceh, Indonesia	32,30	(Musri, 2022)

According to studies conducted in Makassar City, the four categories of fruits and vegetables account for the majority of food waste produced, which is mostly from tegal food booths and canteen services. Vegetables like spinach and kale, protein sources like fish and cattle, and carbohydrates like rice make up the majority of food waste types. Since beef has a high emission factor, the majority of the carbon in the average annual carbon footprint—46.69 kg CO2 equivalent per plate—comes from protein-rich diets (Aqilah, 2022). While Bogor city has a total average carbon footprint value of 62.28 kg.CO2eq/plate/year, Makassar city is undoubtedly smaller than Bogor city. This may be due to the different restaurant types that were investigated; large-scale restaurants were the focus of the Bogor City investigation, whereas tegal stalls predominate in Makassar City. This has an impact on how food is presented differently as well. In tegal stalls, food is provided according on what the customer orders, but in the large-scale restaurants under investigation, a set menu usually includes papaya leaf vegetables, jackfruit vegetables, and green chili sauce on every dish. There are also more dishes available than at tegal booths, which encourages patrons to choose more ostentatious menu items. This leads to a significant amount of food waste being produced by restaurants. Ternate City offers a more haphazard representation of this kind of dining establishment, with vendors serving grilled chicken, rice, soto lamongan, and grilled fish options. Comparing Bogor City to Ternate City, which has a value of 53.3 kg.CO2 eq/plate/year, the overall average carbon footprint of Bogor City is still larger (Muhtar, 2021). This is because several restaurant and food stall kinds were examined. 75% of the overall carbon footprint produced by basic foods is made up of leftover rice, which accounts for the majority of food waste in Ternate City research due to its more randomized approach to the types of food stalls examined. On the other hand, the Bogor City study concentrated on food waste from large-scale restaurants, with 57% of the waste coming from meals high in protein, such as fish, 27% coming from foods high in carbohydrates, such as rice, and 16% coming from fruits and vegetables, which were primarily cassava leaves.

The quantity of food waste produced in Bogor City is still significant when compared to the research conducted in Banda Aceh. An Aceh restaurant using a buffet serving approach was the sort of restaurant under investigation, according to research done in Banda Aceh. According to this study, restaurants with a high concentration of office workers have a larger menu, which results in a greater amount of food waste being produced; conversely, restaurants with a high concentration of student visitors have a smaller menu, which results in a lower amount of food waste being generated. Out of three carbon footprint studies, this

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one had the lowest overall average carbon footprint value of 32.30 kg.CO2 eq/plate/year (Musri, 2022). This may be because, with the exception of fish bones, which are inedible waste, food waste with high emission factors, such meat, is rarely leftover. While Bogor City has an average of 520.9 g/day, the amount of food waste rich in carbohydrates from three restaurants in Banda Aceh is just 441.5 g/day on average.

Factors affecting Food Waste

The food waste produced by each restaurant in Bogor City is often collected first, at random, and without being separated by the business owners. Instead of processing garbage on an individual basis, the restaurant owners work with other stakeholders to send all of their waste to the TPS. The majority of the stakeholders were motorized garbage rickshaws and often used landfills, according to the questionnaire's results. It goes without saying that a number of variables affect food waste in restaurants in Bogor City. A correlation matrix is used to analyze the factors that restaurant owners fill out on a questionnaire that contains potential causes. These variables include the restaurant's revenue, the location where customers buy fruits and vegetables, how far they are from where customers buy meat and fish, how long the restaurant is open, and how many customers often visit. Together with the typical amount of food waste produced, the dependent variable also takes into account the carbon footprint produced. The findings of the survey on restaurant owners' independent and dependent factors are displayed in the following table.

Table 9. Free and dependent variables

Restaurants	Average waste (g/day)	Carbon footprint (g CO2 eq/day)	Distance of meat and fish purchase location (km)	Distance of food staple purchase location (km)	Restaurant operating time (km)	Average Visitors (people)
SP	2.683,4	439,82	1	1	12	85,71
PS	988	184,54	14	14	16	85,71
BA	825,8	125,41	7	7	12	85,71

After obtaining the data, the author utilizes regression analysis to ascertain the correlation coefficient (r) and p-value that will be utilized in the correlation matrix. It is anticipated that using the correlation matrix would give a broad picture of the variables that most affect the production of food waste. The reasons of excessive food waste creation can be identified and then examined to determine the best course of action. After speaking with restaurant owners, the correlation matrix table that follows was created:

Table 10. Correlation Matrix of Research Variables

Factors		1	2	3	4	5	6	7	8
Average food waste generation (1)	Correlation (r)	1							
	p-Value								
Carbon footprint (2)	Correlation (r)	0,8	1						
	p-Value	5							

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Factors		1	2	3	4	5	6	7	8
Distance from where meat and fish are purchased (3)	Correlation (r)	471	117	698	984	1			
	p-Value	170	747	25	3 x 10-7				
Distance to purchase location of food staples (4)	Correlation (r)	57	93	166	361	458	1		
	p-Value	876	798	648	306	183			
Restaurant operating time (5)	Correlation (r)	320	160	113	108	137	477	1	
	p-Value	367	756	756	766	705	163		
Average visitors per day (6)	Correlation (r)	52	236	505	133	112	435	0,52	1
	p-Value	886	512	136	713	757	209	47	

Using the correlation coefficient (r) and p-value can help you decide how to use this correlation matrix. The importance of the correlation between an independent variable and the carbon footprint will be explained by the value of r. Therefore, the more closely the value approaches 1, the greater the impact of the independent variable on the carbon footprint. In the meanwhile, the p-value indicates the degree of significance of the relationship found in this study between the independent and dependent variables. This means that in this investigation, the value of α represents the highest value that may be allowed. In other words, the more values there are, the less the independent variable can explain the dependent variable. For this investigation, a 5% p-value with a 95% confidence level is the minimal requirement. In this study, a r value of more than 0.5 is the criterion.

As can be observed from the correlation matrix given, only the average food waste generation variable is significant among all the hypothesized parameters impacting carbon footprint creation. All other variables are not significant. This is because, with the exception of the average amount of food waste generated, the r-value and p-value of the majority of the factors do not fulfill the requirements to be considered to have a significant impact on the dependent factor (carbon footprint). Nevertheless, despite these restrictions, the correlation coefficient (r) is used to rank each independent variable according to its impact on the dependent variable, or carbon footprint.

Table 11. Ranking the Influence of Independent Variables on Carbon Footprint

Ranking	Factors	r-*value* dan *p-value*
1	Average Food Waste Generation	r = 0,8
		p-value = 0,005
2	Average diners	r = 0,236
		p-value = 0,512
3	Restaurant operating time	r = 0,16
		p-value = 0,756
4	Distance to meat and fish purchasing locations	r = 0,117
		p-value = 0,747
5	Distance to food staple purchase locations	r = 0,093
		p-value = 0,798

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It is clear from the ranking of independent variables based on the resultant carbon footprint's correlation (r) and p-value that the average amount of food waste generated has an impact on each restaurant under study's carbon footprint creation. This is evident from the extremely high correlation coefficient (r) of 0.8 and the fact that the p-value is less than the required minimum of 0.005.

Average number of visits and operational time are placed second and third, respectively, however neither the correlation value nor the p-value are high enough to be considered indicators of how much these variables influence the creation of carbon footprints. These two parameters do have a correlate and it is pretty substantial, according to the correlation matrix. The number of guests and the quantity of food waste produced on that particular day will increase with an extended operating time. This is due to the fact that each guest who eats on the spot has to create food waste, both edible and non-edible trash. The amount of food waste produced will change if there is more of it. This is due to the fact that the carbon footprint is calculated by multiplying the total amount of discarded food by the emission factor. However, the association is not significant and is not highly typical because of sample limitations in each restaurant. The average number of diners and operating time are larger variables than the distance between the site of the purchases of meat and fish and staple foods. Because the computed carbon footprint is from leftover dinner plates rather than from food loss or transit, the distance component has a relatively low association. If food waste is taken into account, which is closely tied to transportation, purchase distance can have a strong link. Furthermore, Pagi Sore Restaurant and Bumi Aki Restaurant, the two large-scale eateries with the largest density in the study, had the lowest carbon footprints, coming in at 88.99 and 136.6 g CO2 equivalent per day, respectively. This is due to the fact that fruits and vegetables make up the majority of the food waste from these two eateries. All restaurants, with the exception of Payakumbuh, which has the highest carbon footprint value, have the same amount of patronage. Furthermore, the questionnaire answers yielded just two population density numbers, with the exception of Payakumbuh Restaurant, which had the same density figure of 85,714 persons per day. The density value is derived from many ranges of values provided in the questionnaire that restaurant owners are required to complete.

Recommended Food Waste Reduction Efforts

In May 2021, the amount of waste generated daily in the city of Bogor increased to 500 tons (Adhi, 2021). The Galuga dump in Bogor Regency will be the final destination for the leftovers produced by 29 TPS3R. Furthermore, DLH Bogor City is educating the locals about maggot farming. This is due to the fact that organic trash, which maggots can break down, makes up the majority of the hundreds of tons of waste. Furthermore, families account for 70% of the garbage produced in the Bogor City neighborhood. The remaining thirty percent is made up of garbage from commercial buildings including offices, service providers, and dealers. As can be observed from the trash sources in Bogor City, homes account for 70% of all waste sources. It is anticipated that the new waste management paradigm of Reduce, Reuse, Recycle (3R) would play a major role in providing a significant solution to the issue of

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household garbage. Reducing excess food consumption and composting at home are two effective ways to combat waste, particularly food waste.

Based on the findings of the study the author performed, the following suggestions for efforts to reduce food waste are provided for the unique situation of restaurants that are part of the big scale are (1) enhancing the manner that upper-class and lower-class restaurants serve rice by requesting in advance what dishes they would want to see served. in order to ensure that no vegetables are wasted or left uneaten, with cassava and jackfruit leaves having the highest percentage in this research and being required to be presented on every dish. (2) To lessen the possibility of wasted rice, provide the rice amount in moderation and let the client to add more if they feel like it.

CONCLUSION

From the findings of the food waste from restaurants in Bogor City's carbon footprint analysis, the following may be deduced (1) The typical amount of food waste produced daily in Bogor City comes from the modest eateries Payakumbuh, Pagi Afternoon, and Bumi Aki. The amount of edible food waste created may reach 12,026.70 g/org/day. It is made up of meals high in protein (14.3%), fruits and vegetables (40.1%), and carbohydrates (45.6%). At 26,834 g/org/day, Payakumbuh restaurant produces the most edible food waste among restaurants, whereas Pagi Sore produces the least amount, 988 g/org/day. (2) In the Bogor City basic restaurants Payakumbuh, Pagi Afternoon, and Bumi Aki, the average annual carbon footprint created by food waste per plate is 8.153 kg CO2eq. With 16.054 kg CO2 equivalent per year, Payakumbuh is the restaurant with the most carbon footprint contribution, while Bumi Aki has the least carbon footprint contribution at 3.326 kilogram CO2 equivalent per year. (3) In order to prevent food waste in the simple houses of Payakumbuh, Pagi Afternoon, and Bumi Aki in Bogor City, managers and restaurant owners can be advised to enhance their serving practices by asking patrons in advance what they would like to be served on a plate to ensure that no inedible vegetables are left behind.

REFERENCE

Abdelradi, F. (2018). Food Waste Behaviour at the Household Level: A Conceptual Framework. *Waste Management*, 485-493.

Adhi. (2021, Oktober 11). *Sampah di Kota Bogor Meningkat Sejak Mei.* Retrieved 2024, from https://www.republika.id/posts/21161/sampah-di-kota-bogor-meningkat-sejak-mei

Amalia, D. Z., & Ar, F. S. (2024). Data Jumlah Sampah Makanan Rumah Tangga Negara-negara di Asia Tenggara. *UN Environment Programme (UNEP)*.

Aqilah, L. D. (2022). *Analisis Jejak Karbon Sampah Makanan Dari Rumah Makan di Kota Makassar.* Jakarta: Skripsi Teknik Lingkungan Universitas Indonesia.

Arikunto, S. (2013). *Prosedur Suatu Pendekatan Praktik.* Rineka Cipta.

Fandeli, C. (2020). *Pembangunan Kota Hijau.* UGM Pers.

FAO. (2011). *Global Food Losses and Food Waste-Extent, Causes and Prevention.* Roma (IT).

FAO. (2014). *Global Food Losses and Food Waste-Extent, Causes and Prevention.* Roma.

Jurnal Info Sains : Informatika dan Sains
Volume 14 , Number 02, 2024, DOI 10.58471/infosains.v14i02
ESSN 2797-7889 (Online)
https://ejournal.seaninstitute.or.id/index.php/InfoSains

IPCC. (2006). *Intergovermental Panel On Climate Change (IPCC).* Guidelines for National Greenhouse Gas Inventories. Energy II.

IPCC. (2007). *Impacts, Adaptation and Vulnerability.* Cambridge University Press.

Kementrian Lingkungan Hidup. (2012). *Pedoman Penyelenggaraan Inventarisasi Gas Rumah Kaca Nasional Buku II Metodologi Perhitungan Tingkat Emisi Gas Rumah Kaca Kegiatan Pengadaan dan Penggunaan Energi.* Buku II.

KMLH. (2022). *Sistem Informasi Persampahan Nasional.* Jakarta: Kementerian Lingkungan Hidup dan Kehutanan.

Levis, J., & Barlaz, M. (2011). The Most Environmentally Beneficial Way to Treat Commercial Food Waste. *Environmental Science Technology*, 7438-7444.

Muhtar, I. (2021). *Analisis Jejak Karbon Limbah Makanan dari Rumah Makan di Kota Ternate.* Tugas Akhir Teknik Lingkungan Universitas Indonesia.

Musri, S. K. (2022). *Analisis Jejak Karbon Limbah Makanan dari Rumah Makan di Banda Aceh.* Jakarta: Tugas Akhir Teknik Lingkungan Universitas Indonesia.

Nur, Y. (2008). *Inventori Emisi Gas Rumah Kaca (CO2 dan CH4) Dari Sektor Transportasi Di DKI Jakarta Berdasarkan Konsumsi Bahan Bakar.* Institut Teknologi Bandung.

Silvennoinen, K., Heikkila, L., Katajajuri, M., & Reinikainen, A. (2015). Food Waste Volume and Origin: Case Studies in The Finnish Food Service Sector. *Waste Manage*, 140-145.

Wiedmann, T. (2008). A Definition of "Carbon Footprint". C. C. Pertsova, Ecological Economics Research Trends. *Nova Science Publishers, 1*.

Wulansari, D. (2019). Kajian Timbulan Sampah Makanan Warung Makan. *Ecotrophic*.