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Food waste in Sodexo restaurant at Metropolia Leiritie

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Almost one-third of food production in the world is wasted every year. Food waste has become an issue of growing interest among companies and governments. Its impact on society, economy and environmental are starting to be recognized and need to be addressed. However, studies of food waste in Finland is still limited in both scale and time, especially at university level. The aim of this thesis is to quantify the amount of food waste at Sodexo restaurant in Metropolia Leiritie. By using a small digital scale, all food waste from Sodexo restaurant has been measured during two months. The collected data is then analysed using basic statistics, and meaningful conclusion has been drawn. Besides, detail ideas of meal reservation for mobile application are also studied and displayed.

An experiment utilizing kitchen biowaste as a compost is also being done in the lab. The objective is to see how well the kitchen waste can turn into compost by just basic procedure. All monitoring values such as O_2 content and temperature is also recorded for quality determination of the composting process.

The result of this study indicates that an average number of 244.10 ± 28.53 g of waste is produced per student per lunch including all mixed and biowaste from preparation to serving stage. Left-over unpurchased food waste is the heaviest type of waste, accounted for almost a third of total waste. There are around 12.5 kg of biowaste everyday suitable for composting. The composting experiment using kitchen waste is considered to be success, as the biowaste successfully turn into darkish compost. However, evidence shows that no thermophilic microorganism has been developed as the temperature did not rise above 35 °C. Thus, human and plant pathogens, weeds seeds and insect larvae might still be present and affect the quality of compost product. In order to see if composting food waste locally should be the main treatment instead of transporting it away to a biowaste plant, a more thorough study is needed.

Keywords	Sodexo, biowaste, food waste, compost, reservation app

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Finally, I would like to express my deepest love to my family, friends who are always by my side and supported me during all this time.

1 Introduction

In recent years, there has been an increasing interest in food waste all over the world. FAO (2011) has estimated that one-third of the world food production, roughly 1.3 billion tons, is wasted annually. In the European Union, around 88 million tones of food are wasted every year; and by 2020, estimates suggest that this will increase to 126.2 million tones per year (Stenmarck, Jensen, Quested, & Moates, 2016). It has been shown that "In medium- and high-income countries, food is to a significant extent wasted at the consumption stage, meaning that it is discarded even if it is still suitable for human consumption" (Gustavsson, Cederberg, Sonesson, Otterdijk, & Meybeck, 2011)

The food waste epidemic has a significant impact on global food security, especially for poor people. Every night, 870 million people go to bed hungry. Each and every one of them would be sufficiently fed if just a quarter of the global food waste could be saved (Global Initiative on Food Loss and Waste Reduction, 2010). Furthermore, food loss is wasting EU economy 143 billion euros annually (Stenmarck, Jensen, Quested, & Moates, 2016). This tremendous amount of money would have been used to help reducing the cost of food and boost development of the economy. In addition, the issue of food loss has been creating serious environmental problems. The food wasted took resources to make; it used up a huge amount of water, land and fertilizer only to be discarded. Then it costs another huge budget just to find the way to efficiently treat those food waste. Due to this severe impact on the economy and environment, necessary measures need to be taken. In order to end this global food waste epidemic, the first step should be to quantify and understand food waste just in our daily life.

In Finland, there have been no large-scale studies in food-waste especially at university cafeteria. Recently, Yle (2017) reported that "2,750 meals are thrown into the garbage uneaten in Helsinki, 1,750 portions in Espoo and 1,050 in Vantaa – each day". However, the whole report is just based on assumption, no thorough measurement has been done. Another research by Katajajuuri (Food waste in the Finnish food chain, 2014) focuses on too many sectors of foodwaste such as household, restaurant and food services, and only lasted for a short period of time. By studying and understanding food waste at university, proper awareness can be raised easily among thousands of students. They can contribute to the reduction of food waste winthin the university and later on spread the awareness to reduce waste in household kitchen.

As a part of Better Tomorrow 2025 plan by Sodexo, the objective of this thesis was to determine the amount of food waste produced in Sodexo restaurant at Metropolia Leiritie and its distribution relative to the number of students eating. Every day, all the waste relating to food services from the restaurant is measured, including food packaging, food production waste in the kitchen, left-over food by students and unpurchased food. Thus, not only left-over food waste is analyzed to demonstrate efficiency of the kitchen and eating behavior of the student, but the waste in order to produce the food is also measured to study the impact of the restaurant food making process on the environment. The number of students having lunch is also noted. The whole measurement period lasts around two months.

In addition, this thesis also presents an idea for the meal reservation mobile app and a practical composting method to treat food waste on site rather than transporting it away to the city treatment center. An experiment on composting waste has been conducted to determine composting rate and characteristics of the bio food waste.

2 Background review

2.1 Sodexo

2.1.1 Sodexo services and Better Tomorrow 2025 plan

As stated on its website, Sodexo is “founded in 1966 by Pierre Bellon in Marseilles, France, is now the worldwide leader in Quality of Life services. For over 50 years, Sodexo has developed unique expertise, backed by nearly 427,000 employees in 80 countries across the globe”.

Sodexo provides food services and facilities management in various sectors, including private corporations, government agencies, schools from pre-school to university, hospitals and clinics, assisted-living facilities, military bases, and prisons (Sodexo Wikipedia, n.d.).

Better Tomorrow 2025 is a plan set out by Sodexo to achieve nine commitments that would make life better for individuals, communities and the environment. One of the biggest challenge that Sodexo committed to tackle is food waste. With a supply chain of over 150,000 enterprises, 425,000 employees and 75 million consumers, Sodexo has a

potential to revolutionize the way food serving industry deals with food waste. Some programs and campaigns have been established by Sodexo to help identify causes, define action plans, and educate people of food waste such as WasteWatch and WasteLESS Week. Following Better Tomorrow 2025 plan, this study is conducted to get a thorough understanding of Sodexo food waste at Metropolia Leiritie.

2.1.2 Sodexo restaurant at Metropolia Leiritie

The restaurant kitchen is currently preparing food for approximately 800 students and staff at Metropolia Leiritie. Lunch and evening meals are served everyday, except on Friday, when there is no evening meal. There are a large number of options on the menu, ranging from main dishes, soup, and dessert to vegetarian, special lunch and sandwich. Food is served in a similar style of buffet; however, one can only pick one kind of main dish, while other food can be freely added like rice, pasta, noodles and vegetables. It is worth noting that Sodexo restaurant only limit portions of some dishes such as sausages or chicken, while the rest of the dishes are up to the buyers; they can get as much as they want as long as it fits on one plate. On the other hand, the food price at Sodexo restaurant is subsidized by Kela; thus it is very affordable to the student in general, and has become a go-to lunch option for many students.

However, lacking the information of number of students eating in advance and having lots of options in the menu, the restaurant is definitely not having an easy task serving enough food in time. In addition, it also struggles to be efficient and environmentally friendly and wastes a large amount of fresh ingredients and left-over food.

Every morning, the chef will estimate the amount of food that the kitchen will cook for lunch based on her experience. Therefore, it can sometimes happen that there are so many students eating compared to the amount of prepared food, while sometimes there is just a small number of students having lunch, which leads to a huge amount of left-over food being thrown away. The problem of not knowing beforehand how many students will be eating that day is the main reason why there are so much waste being produced everyday.

Moreover, there is no chef in the evening to cook the evening food, and all evening food has been pre-cooked at lunch time. Since the number of students in the evening fluctuates considerably, and in order to prevent not having enough food to serve students, the

kitchen always has to pre-make food for like 75 people, a rather “safe than sorry” approach, despite knowing that there might be only about 20 students eating. The inevitable result is a large amount of waste from left-over food even with a moderate number of students.

Furthermore, having lots of options in the menu also seems to exaggerate this problem. Some dishes might unexpectedly be consumed faster and to a greater extent than others, at the result, new food need to be cooked quickly and some food will become left-over and wasted. For example, consider a hypothetical situation, on the menu, kitchen is serving sausage with a very delicious sauce and pea soup. In the morning, the chef estimated about 100 sausages and 100 pea soup portions to be cooked. Unfortunately, at lunch, nobody likes pea soup, everyone just loves the sausages dish and it runs out so quickly that the kitchen has to quickly cook new sausage to meet the demand. Meanwhile, there is a lot of pea soup left over and being served to nobody. Then after lunch time has ended, pea soup will be thrown away, which results in a lot of food waste.

2.2 Food waste at university restaurant

The notion of sustainability has become ubiquitous in our modern society. It is defined as development that meets the need of our present without compromising our future generation’s need. With the issue of increasing global warming, the requirement to reduce our energy consumption and pollution through minimizing waste has become critical to maintain our environmental sustainability.

University plays a critical role in developing environmental sustainability awareness, educating and graduating environmental responsible students. University restaurants are also realizing their role in this movement. Numerous researches have been conducted at the university cafeteria in order to provide reasonable insights into key areas for potential food waste reduction.

Engstrom and Carlsson-Kanyama (2004) found that at two schools in Stockholm they investigated, 115 and 46 grams of food is wasted per portion served. Of which, 9% to 17% is lost through preparation, 6% to 56% is unpurchased food and 3% to 76% is left-over food on plate. However, the study only lasted two weeks, which is probably a short time to get a proper picture of food loss. Preparation losses consisted of only peel from

tubers and vegetables. Thus, this study does not include waste occurring during storage and serving stages of food such as carton, metal and hand paper.

Ann C. Wilkie (2015) investigated Food Waste Auditing at three Florida Schools and found that in a public elementary school cafeteria during lunch time, 137.6 g of food waste is disposed by each student every day, which constitutes of 47.1% food waste, 15.3% paper and 0.3% metal. In another public high school, 99.01 g of food waste is produced by each student everyday which, constitutes of 57.8% food waste, 16.4% paper and 4.8% metal. However, the study period of both schools are only 8 days and 7 days, which is quite short.

At Rhodes University in the Eastern Cape province of South Africa, a meal reservation system was introduced to let students book their meal 48 hours in advance. At meal times, after going through a biometric recognition system (fingerprint scanning) student will get the meal option that they chose days before. Food portion sizes are consistent for all students and are governed by the serving staff. During 21 days of observation, Kathleen Painter (2016) found that at lunch waste produced per student per meal is 155 ± 66 g, but no waste during food preparation and serving is recorded.

2.3 Current research on composting kitchen food waste

”Composting (from the Latin compositum, meaning mixture) refers to a biodegradation process of a mixture of substrates carried out by a microbial community composed of various populations in aerobic conditions and in the solid state” (Insam & Bertoldi, 2007). The output of this process are carbon dioxide, water, minerals and compost. The main product, compost, is an organic fertilizer that is beneficial for plant growth. The reason why meat is usually avoided in composting is that meat usually attracts pests, contains harmful pathogens to human and tends to smell (Grant, 2018).

Four process phases of composting are described by Insam & Bertoldi (Microbiology of the Composting Process, 2007) as follows:

1. *Mesophilic Phase (25°C to 40°C):* Easily degradable compounds like sugars and proteins are degraded by fungi, action bacteria and bacteria. The activity of mesophilic bacteria induces a rise in temperature.

2. *Thermophilic Phase (35°C to 65 °C):* Organism adapt gradually to high temperature and at the end, mesophilic organisms die off and are degraded by thermophilic organisms. The decomposition process continues to be accelerated and so does the increase of temperature. Despite the ideal temperature for thermophilic fungi growth are from 35 to 55 °C, the temperature keeps rising further and may reach 80 °C, lead to destruction of microorganisms. This phase is important for hygienization as human and plant pathogens are destroyed and weed seeds and insect larvae are killed.
3. *Cooling Phase (Second Mesophilic Phase):* Due to depleting substrate, the activity of thermophilic organism ceases and the temperature starts to decrease. At the result, Mesophilic organisms take over the substrate especially those that degrade starch or cellulose.
4. *Maturation Phase:* Composting process finishes and stabilizes

Factors affecting this process are substrates, temperature, pH, aeration and moisture content. During the composting process, the carbon dioxide content gradually increases while the oxygen level falls. Oxygen concentration varies from 15% to 20%, and carbon dioxide from 0.5% to 5% (Macgregor, Miller, Psarianos, & Finstein, 1981). A moisture content of 40-60% by weight would be ideal for composting (University of Cornell, n.d.). However, concise compost maturity and quality criteria still are lacking, and usually do not include microbiological aspects, despite the fact that microbial activity is the major process for compost production and utilization (Insam & Bertoldi, 2007).

A local composting station would bring a huge benefit in transporting of both input and output of composting. However, other technical factors should be taken into consideration such as storage, processing, product quality and most importantly the drawback of downscale. An experiment using kitchen biowaste at Metropolia Leiritie as compost has been conducted in order to determine the feasibility of this composting station plan.

2.4 Mobile application for lunch at other university food services

Since late 2017, Frank and MobilePay have cooperated to enable quick lunch payment through their application (app) with no student card and credit card needed. The campaign have been launched in various universities and schools in Finland such as Haaga-Helia UAS and Aalto University (Frank ❤ MobilePay, 2018). There is no need to carry a student card and a credit card anymore to pay for lunch when using this app. By opening

MobilePay app and bring the phone near the MobilePay Payment Sensor, lunch is paid immediately, no need to waste time anymore in a long queue. Despite this app being widespread, there are still numerous problems occurring such as difficulty to recognize foreign students. Especially, this app lacks the function to make meal reservations in advance which is the most important feature to improve efficiency in the kitchen. Therefore, new feature need to be added to this app or a whole new mobile app is to be created.

3 Equipment and methods

3.1 Equipment

3.1.1 Measuring food waste

Vetek shipping scale FCS 150 is a new digital scale which has a maximum capacity of 150kg and a 0.01g resolution.

Figure 1: Vetek shipping scale FCS 150

The original idea was to utilize this scale as an automatic weighing station. A student waste bin was to be put on top of the scale, and the weight of the waste was to be continuously recorded. Then all the collected data were to be transferred to a computer, where useful information was to be calculated in real-time and later put on a screen in middle of Metropolia cafeteria. The purpose of this screen was to raise awareness of the huge amount of waste that students produce and later on, if possible, would be a main communication tool for the Reducing Food Waste campaign. However, the function of this scale was just minimal and not able to perform such tasks. Instead, this scale was

used by simply putting the waste on top and the measured values were recorded on paper

3.1.2 Food composting

A metal cylinder bin, was provided from the lab and used as a composting bin. It has a volume of 42.4L, a rotating mechanism by hand, two air ventilation holes on each side and measuring holes with rubber cap for CO_2, O_2 and temperature measurement. A foundation was also put below the bin in order to capture all possible leakage of waste and water.

3.2 Methods

3.2.1 Waste monitoring procedures

Everyday, food waste was disposed of after lunch by the kitchen staff. A weighing station was set up near the back door of environmental lab, as it is also located on the path from the kitchen to waste disposal area. This location is quite convenient for both kitchen staff and measurement process, as it does not require trash to be brought somewhere else to measure other than its normal path and all measuring equipment are already in the lab (Figure 2).

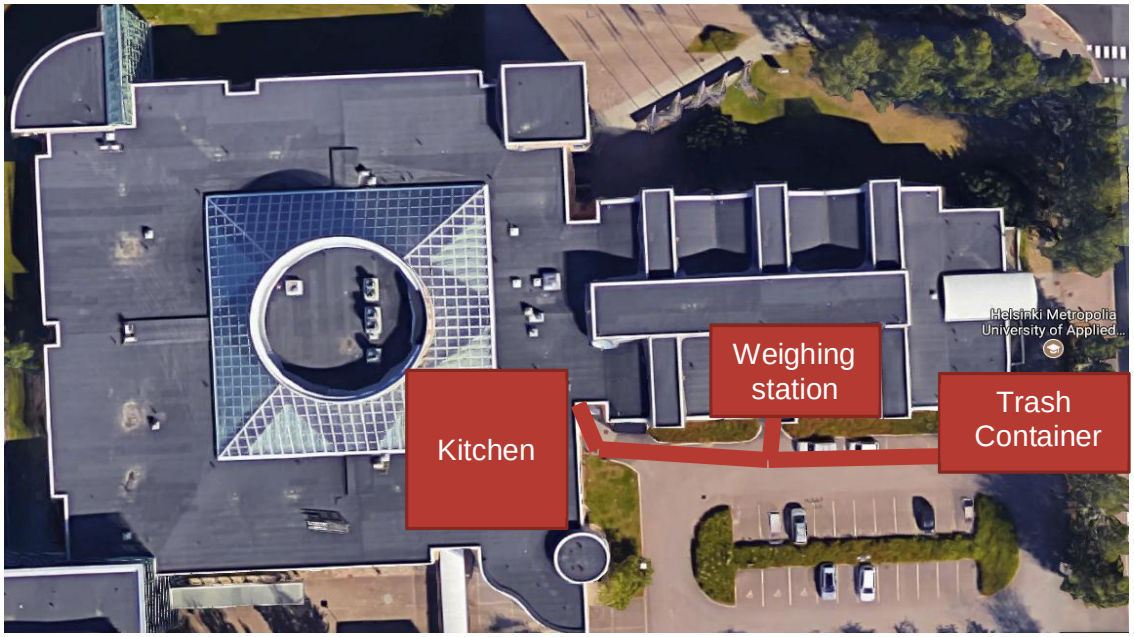

Figure 2: Metropolia Leiritie map

The weighing process was conducted after lunch from Monday to Friday by either the author of this thesis or with the help of the innovation group. We also decided to perform this measurement in the evening around 6 p.m. in some weeks in order to get some data for evening meal. The whole waste measuring process lasted two months.

The weighing procedure started by preparing electricity for the scale, then each bag and bin of waste was put on the scale by kitchen staff. It is worthy to note that all the waste had been sorted and disposed of in their proper bin. All measurements of each waste type were recorded and put online for group access.

The measured food waste included all waste from the kitchen in preparation and serving food process. This means that not only bio food waste was recorded but also all the mixed waste produced by food packaging (e.g. carton, metal, coffee cups). All the food waste is categorized as in Table 1 the below.

Table 1: Waste description

	CATEGORY	DESCRIPTION
Mixed waste	Kitchen mixed waste	Plastic wrap, hand paper, glass bottle, etc.
	Metal	Metal cans
	Student mixed waste	Hand paper, coffee cup, etc.
	Milk boxes	Milk boxes, hand paper
	Cardboard	Cardboard for food packaging
	Coffee cup, cashier	Coffee cup, receipt from cashier, etc.
Biowaste	Kitchen biowaste	Biowaste during food preparation and left-over food
	Student biowaste	Left-over food from student dish
	Coffee ground	Wet coffee ground from the coffee machine

Later on during the measurement, to get a better understanding of biowaste produced in the kitchen, kitchen biowaste is subcategorized into compost waste (non-meat waste), left-over food and kitchen biowaste.

3.2.2 Composting kitchen waste

To start off the composting process, 11.5 kg of biowaste (contained no meat) and 1.19 kg of coffee ground is added to the bin. It is rotated regularly every week in this 5-week period to improve air ventilation and mixing. Two beakers were also used to measure the water content of the compost material being used in the beginning.

Later, due to the high content of water, dry material was added into the compost mixture to increase porosity and prevent leachate. Proper water content was determined by squeezing the compost material; if there was water dripping, dry material was added till no water was dripping when squeezed. 1.36 kg of dry material was added after 2 days then 0.98 kg after 1 week and 1.23 kg after 2 weeks. Thus, a total of 3.58 kg of dry material was added.

After 5 weeks, by visual testing, the composting process is finished. Two samples of the compost is collected and weighted, then put inside the drying chamber for 12 hours and weighted afterward. The water content of compost is determined by subtracting two values.

3.2.3 Mobile app for reservation

Balsamiq at balsamiq.com was used as a wire framing tool to create a template for this mobile application. The app must have the following features:

- Easy user registration that is able to check eligibility for subsidized meal cost.
- Meal reservation at least one day before.
- Online credit card payment through the app.

4 Results and Analysis

4.1 Measured food waste

All the food waste from Sodexo restaurant at Metropolia Leiritie was measured in the period from 2/10/2017 to 23/11/2017. The total of 4.6 tons of waste has been measured at 14 evening meals and 31 lunches during that period. At one lunch, mixed waste was not being recorded; thus, the whole lunch measurement for that day has been omitted from calculation. As shown in Figure 3, approximately three quarters of total waste is biowaste (3266 kg), the remaining is mixed waste (1241 kg).

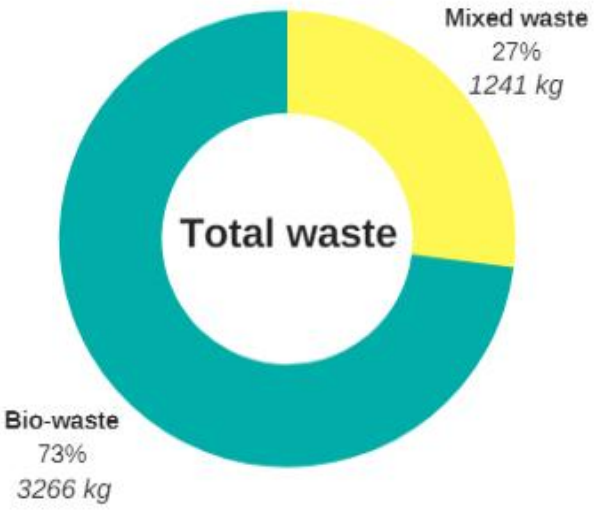

Figure 3: Composition of total waste (Mixed vs Bio)

Figure 4: Composition of total waste (Lunch vs Evening)

Every week, from Monday to Thursday, both lunch and evening meals are being served. On those days, the produced food waste at lunch is 129.62 ± 31.79 kg and significantly less in the evening at 24.11 ± 11.56 kg (Figure 4)

4.1.1 Lunch

During almost 2 months of measuring, 30 lunches were recorded. Food waste varied from 64 kg to 231 kg, in which, biowaste had the biggest impact on the variation. The fluctuation of food waste at lunch is depicted in Figure 5.

On average, the amount of waste that is produced at lunch from Monday to Friday is 138.8 ± 30.9 kg. Of which, 70.16% is biowaste and 29.84% is mixed waste. In the bio-waste category, kitchen waste accounted for 45.5% of total waste, followed by coffee ground and student biowaste (both at 12%). The mixed waste is only accounted for 29.8% of total waste, of which the majority is cardboard at 11.6%, followed by kitchen

mixed waste at 9.7%. The composition of total waste and its mean value at lunch is illustrated in Table 2.

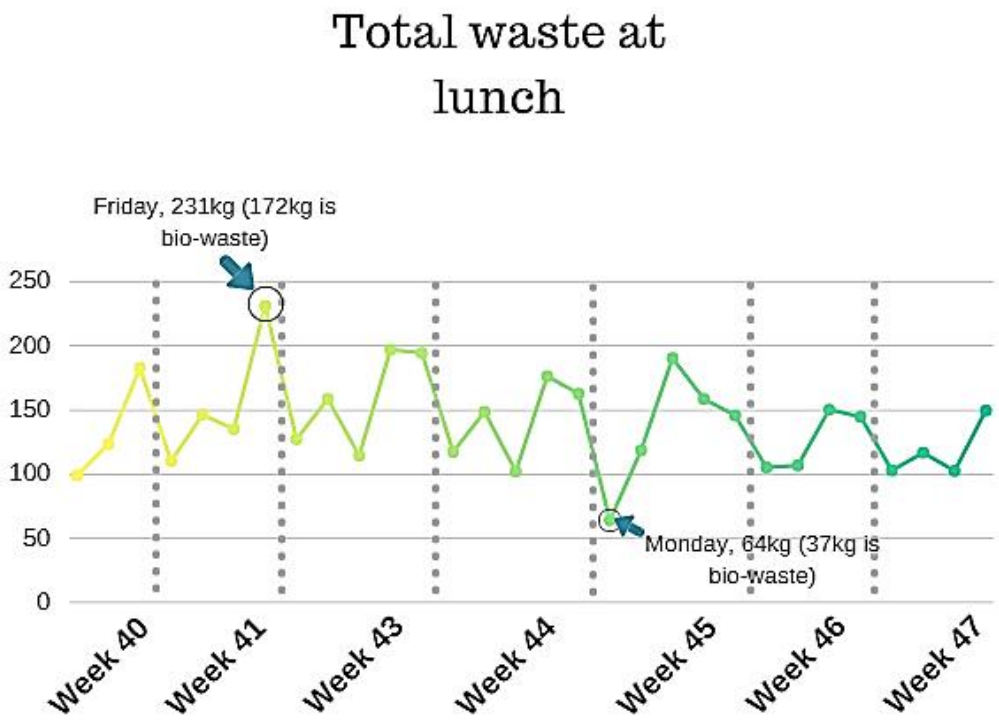

Figure 5: Lunch food waste during the measurement period

WASTE CATEGORY	MEAN (KG)	STANDARD DEVIATION (KG)	PERCENTAGE
Kitchen mixed waste	13.43333	4.627715	9.68%
Metal	3.278	1.548661	2.36%
Student	2.717241	0.810784	1.96%
Milk	3.503704	1.275579	2.52%
Cardboard	16.13966	5.885399	11.63%
Coffee, cashier	2.33	1.42178	1.68%
TOTAL MIXED WASTE	**41.40193**	**7.921992**	**29.84%**
Kitchen biowaste	63.04833	28.77575	45.44%
Coffee ground	16.99667	3.626648	12.25%
Student	17.31167	7.095952	12.48%
TOTAL BIOWASTE	**97.35667**	**29.85882**	**70.16%**
TOTAL WASTE	**138.7586**	**30.89186**	**100%**

Table 2: Composition of total waste at 31 lunches

In order to get a better insight of the kitchen biowaste, it was sorted into compost waste and left-over waste in last two weeks of the measurement (Figure 6).

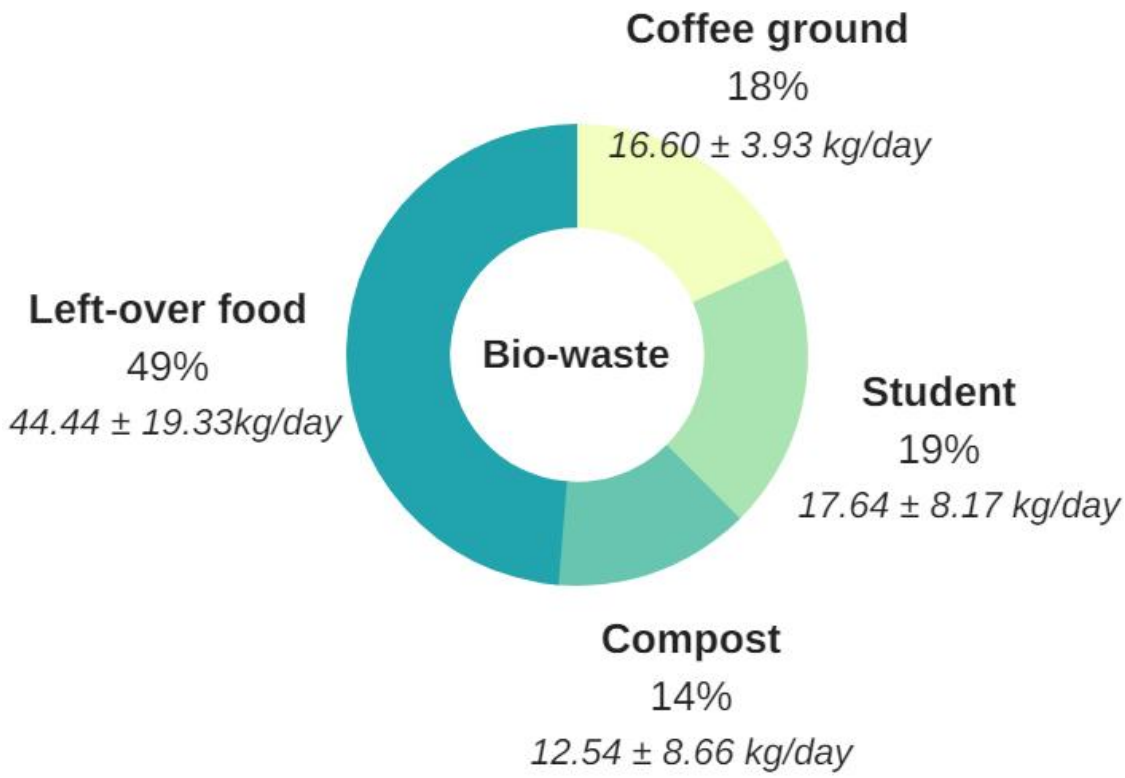

Figure 6: Composition of Bio-waste

It is obvious that left-over food accounted for the most weight in biowaste at 49%. Since the bio-waste made up to 73% of total waste, left-over food is the biggest source of waste in Sodexo restaurant at 35.77%.

The average total food waste on every Monday, Tuesday, Wednesday, Thursday and Friday are illustrated in Table 3. A one-way ANOVA test has been conducted to compare the amount of food waste in different days of the week. The results show that there was a significant difference between the amount of food waste at $p<0.05$ level in all days of the week [$F(4, 25) = 7.137$, $p = 5.61602E-04$]. Post hoc comparisons using the Tukey HSD test indicated that there was a significant difference at $p<0.05$ in the mean food waste between Friday and Monday, Friday and Wednesday, and Monday and Thursday. No significant difference between other pairs of days of the week was found. In other words, the result suggests that food waste is usually disposed of the least on Monday and the most on Friday than any other days of the week.

	MEAN (KG)	STANDARD DEVIATION (KG)
Monday	103.26	19.95
Tuesday	137.31	18.94
Wednesday	124.8	34.2
Thursday	158.77	25.20
Friday	176.49	33.14

Table 3: Average total food waste at lunch during each day of the week

The number of students having lunch varies from around 400 to over 750 everyday. The fluctuation of students having lunch is shown in the figure below.

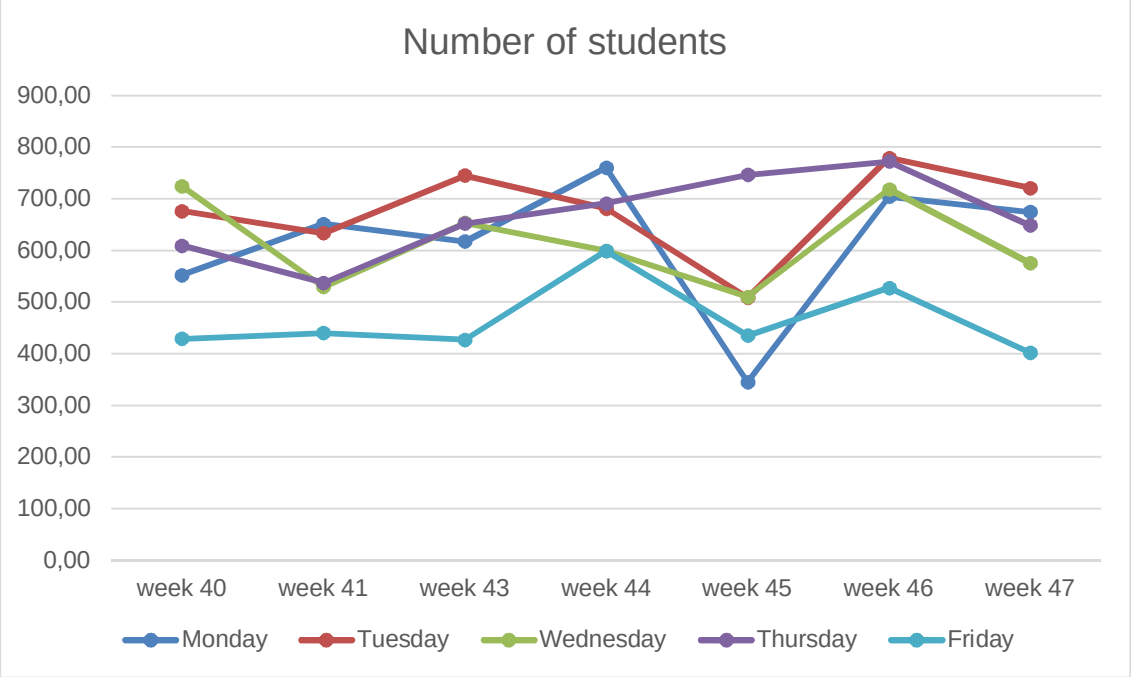

Figure 7: Number of students in the measuring period

From Figure 7 and Table 4, we can see that the number of students having lunch on Friday are far less than on other days despite a having relative high amount of food waste produced as pointed out previously. This result indicates that there must be a hidden factor resulting in high amount of food waste on Friday.

	MEAN (NUMBER OF STUDENT)	STANDARD DEVIATION
Monday	612	126
Tuesday	678	82
Wednesday	615	79
Thursday	655	79
Friday	466	70

Table 4: Average number of student at lunch during each day of the week

It is intuitive that the number of student would have an affect on total food waste. However, the result from a correlation coefficient between the number of students and total waste at lunch produced (r=-0.145) shows that total food waste and number of students are not related (Figure 8). Even the correlation coefficient between number of student and students biowaste, which is the waste that student directly disposes of at lunch shows a very week relation (r=0.469).

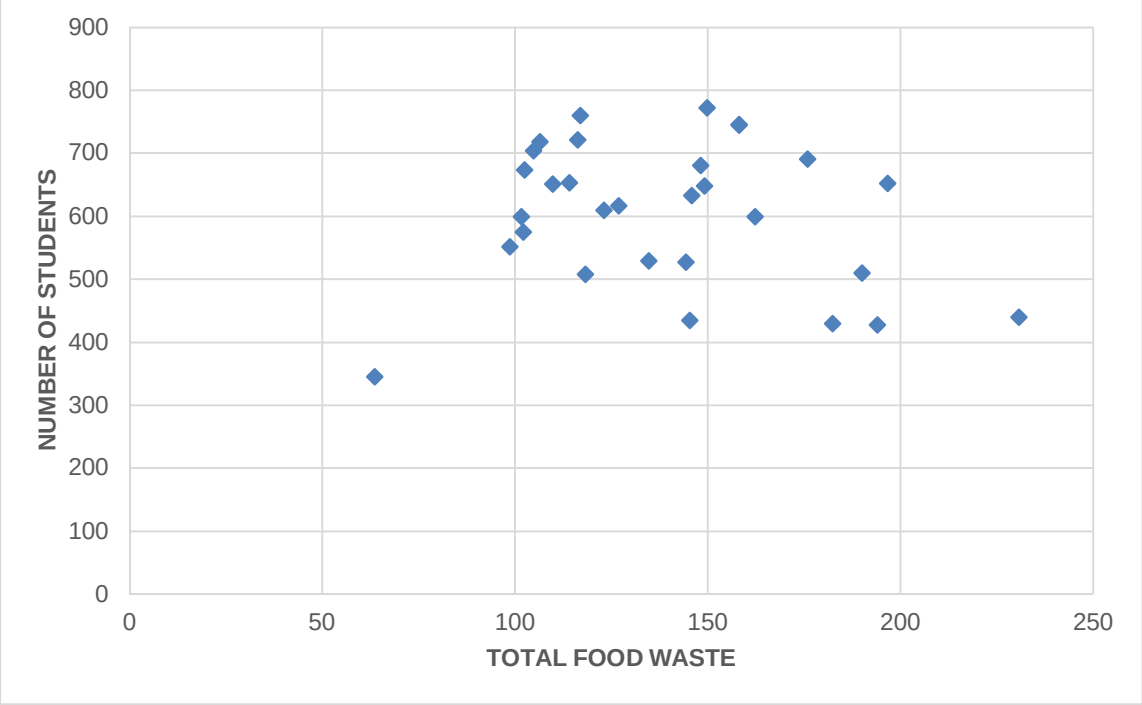

Figure 8: Total food waste relative to number of students

On the other hand, total waste that student produces everyday is calculated by dividing the total waste produced in a week to number of students in that week. The reason this is a proper way to calculate waste per student is that the food waste are sometimes from

the day before. Therefore, it would be inaccurate to calculate based on total waste and number of student in the same day. All the food waste is disposed of on Friday after the weekly cleaning, so it is certain that the waste in one week does not contain any from other week. The result of this weekly basis calculation is 244.10 ± 28.53 g of waste per student per lunch. The only downside of this calculation is that full week data of waste only available in three weeks.

4.1.2 Evening meal

Evening meal is only available from Monday to Thursday. Since all the food is prepared at lunch, food waste after evening meals does not include any preparation waste, which means that there are far less waste types. Furthermore, student's biowaste and mixed waste are usually not disposed of due to such a little amount, which leaves the food waste in the evening with the kitchen's mixed waste, milk, coffee and cashier and kitchen's biowaste (the only type of biowaste).
Table 5 sums up the food waste that was produced in the evening.

Waste in the evening	**Mean (kg)**	**Standard deviation (kg)**	**Percentage in total waste**
Total mixed waste	5.65	3.71	21.96%
Total Biowaste	20.075	10.54	78.037%
Total waste	25.725	11.17	100%

Table 5: Food waste in the evening

Compared to the respective mean value, the standard deviation of total waste in the evening is quite large. The reason for this is a small population of only 14 measurements and a low mean value.

4.2 Composting

After measuring the weight of two beakers containing fresh waste used for composting, the average moisture content was 87.4% in the mixture of fresh kitchen biowaste and coffee ground.

The content of oxygen and carbon dioxide, and temperature inside composting bin was checked regularly. However, the carbon dioxide sensor was giving fault values and took so long to respond, so its data were not reliable. Figure 9 and Figure 10 display the changes of those values throughout the course of composting.

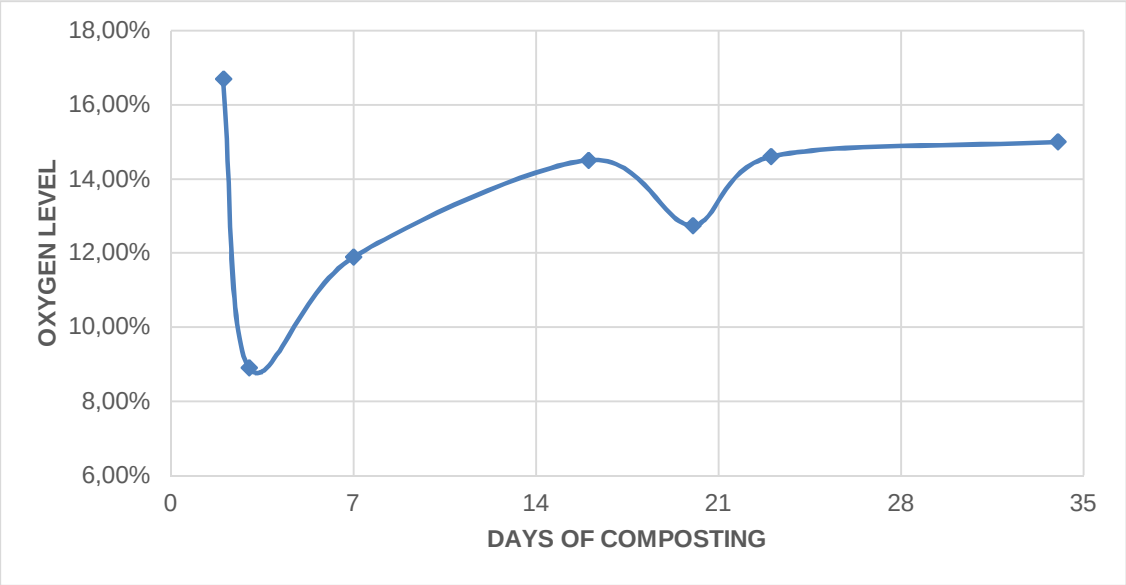

Figure 9: Oxygen level during composting

Oxygen level quickly dropped to 9% only after a few days of composting, then slowly increased and stabilized after 16 days at 15% (Figure 9). Temperature quickly increased to 26°C only after a few days of composting then slowly degrease and stabilized at 19°C (Figure 10). It is obvious that the thermophilic phase, at which temperature reaches 35°C to 65°C was not reached. Therefore, no thermophilic microorganisms were developed, these microorganisms are very crucial for human and plant hygienization as they destroy pathogens, kills weed seeds and insect larvae.

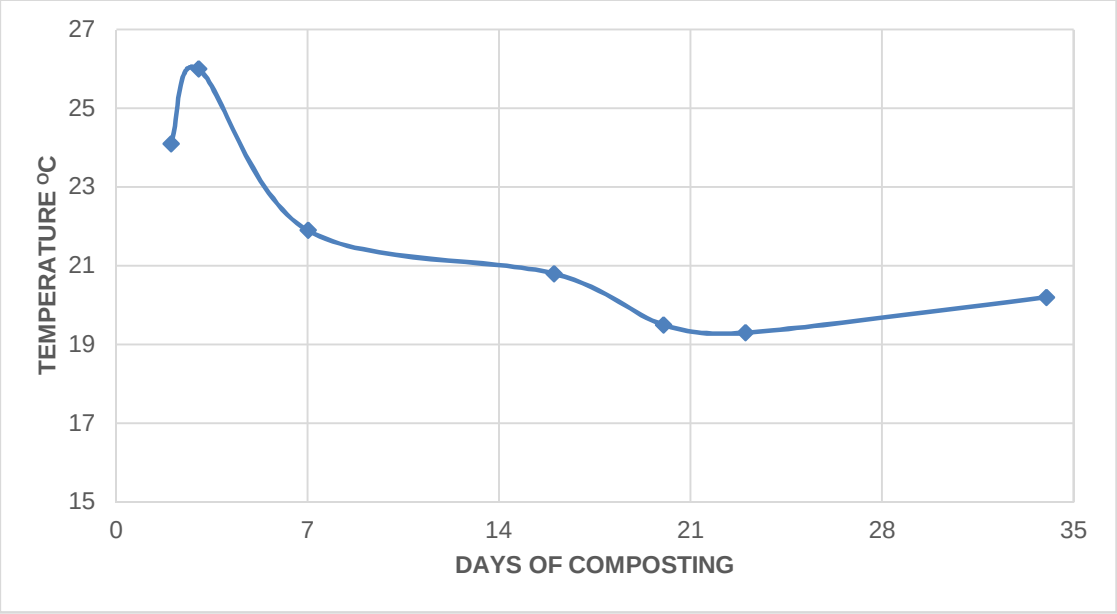

Figure 10: Temperature during composting

By visual testing and sense of smell, the composting process is considered finished. The initial total weight of material for compost is 16.26 kg; after the experiment, the compost weighed 12.45 kg. The loss of weight is mostly due to water dripping and evaporating out of the bin. Mean water content of the finished compost is approximately 47.75%, reduced from 87.4% in the original mixture.

4.3 Reservation app

The app is logged in by using Metropolia account (Figure 11). By connecting to Metropolia, basic information can be obtained such as name, student ID and most importantly eligibility for subsidized meal price. After log in to the account, students can schedule meals that they would like to buy in advance (Figure 12). Then, meal options are shown for the chosen days for student to buy (Figure 13). Detail picture, description price and even feedbacks of dishes are fully displayed. After choosing all the meals in advance, a purchase screen is popped up with various payment methods (Figure 14). When payments have been completed, a receipt is displayed for every meals being purchased (Figure 15). It also contains a barcode or QR-code that enable purchase information to be easily read and confirmed by cashier machines. Finally when lunch time comes, students just need to show the receipt on their phone to the cashier, then all information is collected by a scanner and displayed on screen. The meal is then confirmed and students are ready to enjoy their meal.

Figure 11: Homescreen

Figure 12: Schedule

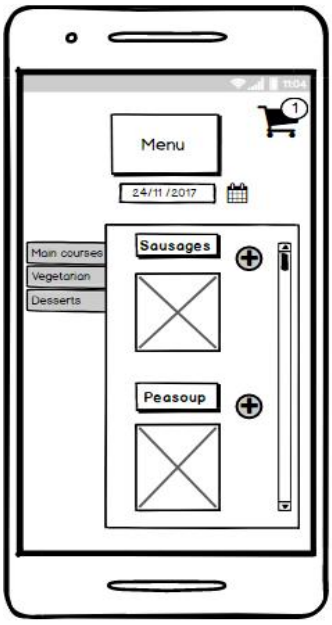

Figure 13: Menu

Figure 14: Payment

Figure 15: Receipt

5 Discussion and conclusion

5.1 Food waste at Sodexo restaurant in Metropolia Leiritie

During the 2-month period, the food waste of 14 evening meals serving 10 to 70 students and 31 lunches serving 400 to 800 students were recorded and analyzed.

The amount of waste that is produced at lunch is five times more than in the evening, at 138.8 ± 30.9 kg and 24.11 ± 11.56 kg, respectively. Of this waste, more than two third is biowaste and less than one third is mixed waste.

The amount of waste at lunch fluctuates significantly during the weight monitoring period, it peaks at 231 kg and might be as low as 65 kg. There is no correlation between the number of students having lunch and the amount of food waste. The reason probably is because hot food waste is usually kept to cool down before throwing it away for safety reasons, and it might have to wait for a night before being disposed of. Thus, food waste of one day might contain some from the day before, as the result, it does not correspond fully with the number of students having lunch. In order to minimize this lag, waste per lunch per student was calculated based on a weekly value of waste and student. However, the inefficiency of Sodexo kitchen should not be underestimated as it plays an important role in producing an enormous amount of left-over unpurchased food waste.

The reason why food waste in the evening varies notably has been explained in the beginning. There are no chef in the evening and no certainty of how many students will have their evening meal, so the kitchen has to precook evening meal to serve for at least 70 people to make sure all students are served. Therefore, if there is even just a moderate number of student buying meals, a large amount waste is still being produced.

Left-over food waste is the biggest part of total waste, accounted for more than a third of it. The heaviest mixed waste are cardboard and kitchen mixed waste, which basically food packaging waste. Surprisingly, the students' biowaste, which is left-over food on plate only account for more than ten percent of total waste.

On every Friday, kitchen is doing a full cleaning, which means that they dispose of all food in the fridge that is not considered safe to consume on next Monday. They also get rid of all left-over food and ingredients that usually left for the next day. These are the

reasons for why Friday is usually the day that generate the most waste despite having the least number of students having meals.

An average number of 244.10 ± 28.53 g of waste is produced per student per lunch include all mixed and biowaste from preparation to serving stage. Of which, more than a third, 87.31 ± 10.20 g is left-over, unpurchased food. If only biowaste (excluding coffee ground) is taken into account, only 141.38 ± 16.52 g of waste is produced per student per lunch. Comparing results of other institutions with the same waste criteria, waste per student per lunch at Sodexo Metropolia Leiritie is at an average level (155 ± 66 g at Rhodes University and 137.6 g at Florida schools) (Painter, Thondhlana, & Kua, 2016; Wilkie, Graunke, & Cornejo, 2015).

5.2 Composting

To a certain extent, composting kitchen food waste experiment was a success. After 5 weeks, compost was produced at an acceptable moisture level of 47% and stabilized temperature and oxygen content. The change in visual to dark-brownish color also indicates that the composting process had ended. However, evidence shows that no thermophilic microorganisms were developed as the temperature did not rise above 35 °C. Thus, human and plant pathogens, weeds seeds and insect larvae might still be present in the compost product.

As found out in the waste measuring period, an average of 12.54 g of biowaste suitable for compost is produced everyday by the kitchen or about 400 kg every month. In order to find out whether biowaste should be composted locally at Metropolia or be transported to a biowaste plant, intensive Life Cycle Assessment and more thorough experiments with cooperation from biowaste plant need to be conducted. The advantage of composting locally is that it reduces transportation fuel cost and offers an easy access to compost for Metropolia. While its drawbacks include more plastic bins and equipment being purchased, labor being necessary needed to maintain proper composting process and enough space being allocated for composting. The carbon footprint of plastic bins and equipment themselves, quality of compost, emission during composting, output of 400 kg compost every month, all should also taken into consideration in future research.

5.3 Limitation

Even though all the waste is supposed to be sorted by students and kitchen staff, there are quite much waste not ending into the right bin. This might have affected the result of each different waste weight, but not the whole total food waste weight.

The type of dish might also have affected the result of waste. Some unavoidable food waste such as chicken bones and water melon shells would result in heavier food waste at certain lunches.

The main focus of this thesis was just on the weight of food waste ignoring the volume it displace. It is worthy to note that while being one of the lightest type of waste, cardboard occupy the most amount of space. In contrast, biowaste is the heaviest type of waste but takes up the least space. The different characteristic in volume and weight of every waste type would create substantial problems in storage and transportation of waste.

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Appendix

Appendix 1: Raw food waste data

	Mixed Waste							Bio-waste						
Date	Kitchen	Metal	Student	Milk	Cardboard	Cafe, cash	Total mixe	Kompostiii	Left over fo	Kitchen	Coffee	Student	Total Bio w	Total waste
Monday 2-10	5.9	4	2.25	4.05			16.2			61	11.35	10.05	82.4	98.6
evening	5.6			0.9		1.25	7.75			47.1			47.1	54.85
Thursday 5-10	9.25	3.5	3	3.15	8.05	5.2	32.15			58.75	16.85	15.25	90.85	123
evening	4.6			0.9		0.8	6.3			15			15	21.3
Friday 6-10	14.2	2.7	2.35	3.35	16	2.05	40.65			110.25	13.1	18.3	141.65	182.3
Monday 9-10	11.45	4.25	1.8	2.75	11.2	1.1	32.55			52.55	13.9	10.75	77.2	109.75
evening						1.15	1.15			19.45			19.45	20.6
Tuesday 10-10	11.85	1.4	2.75	5.7	23.5	0.5	45.7			58.95	18.7	22.5	100.15	145.85
evening							0			12.75			12.75	12.75
Wednesday 11-10	14.85	2.8	2		14.95	1.1	35.7			62.05	20.7	16.25	99	134.7
evening							0			32.05			32.05	32.05
Thursday 12-10	N/A	N/A	N/A	N/A	N/A	N/A	N/A			82.85	19	17.5	119.35	N/A
evening	4.3			0.8		1.4	6.5			13.2			13.2	19.7
Friday 13-10	23.25	2.55	2.45	4.8	25	0.6	58.65			138.65	15.5	17.9	172.05	230.7
Monday 23-10	10.25	4.1	2.45	2.35	8.7	2.4	30.25	21.45		42.65	13.9	18.6	96.6	126.85
evening						1.5	1.5			8.9			8.9	10.4
Tuesday 24-10	10.15	8.95	3.15	2.8	28	3.2	56.25			58.95	21.1	21.85	101.9	158.15
evening							0			24.25			24.25	24.25
Wednesday 25-10	11.85	5.55	2.25	3.8	11.9	3.45	38.8	7.3		34.2	17.45	16.3	75.25	114.05
evening	1			0.9			1.9			18.05			18.05	19.95
Thursday 26-10	16.55	3.9	2.8	5.45	11	0.75	40.45	22.5		94.55	17.85	21.25	156.15	196.6
evening							0			18.75			18.75	18.75
Friday 27-10	12.4	2.9	2.3		30	1.4	49			115	19	11.05	145.05	194.05
Monday 30-10	11.35	3.5	2.6	3.65	9	1.75	31.85			52.7	16.15	16.25	85.1	116.95
evening	3.4			1.15		3.85	8.4			30.8		0	30.8	39.2
Tuesday 31-10	13.45	2.35			20	4.55	40.35			55.9	19.7	32.2	107.8	148.15
evening	11.3			1.7			13			13.85			13.85	26.85
Wednesday 1-11	12.3	1.7	2.3	2.2	15.1	3.7	37.3	2.65		31.6	17.6	12.5	64.35	101.65
evening	2.05		3.3			1.15	6.5			8.3			8.3	14.8
Thursday 2-11	14.35		2.8	3.05	10	2	32.2		46.25	54.85	23.45	19.1	143.65	175.85
evening	1.35					2.15	3.5			18.6		0	18.6	22.1
Friday 3-11	13.4	4.15	3.7	3	15	1.55	40.8	26.95		37.45	21.7	35.4	121.5	162.3

	Mixed Waste							Bio-waste						
Date	Kitchen	Metal	Student	Milk	Cardboard	Cafe, cash	Total mixe	Kompostiir	Left over fc	Kitchen	Coffee	Student	Total Bio w	Total waste
Monday 6-11	5.3		1.65	3.8	15	0.7	26.45	8.55	12.85		9.3	6.4	37.1	63.55
Tuesday 7-11	11.65	2.95	1.8	3.85	22	1.65	43.9	5.85	51.9		8.45	8.1	74.3	118.2
Wednesday 8-11	29		4.35	6.25	11.65	3.2	54.45	7.8	56.6	32.2	20.8	18.1	135.5	189.95
Thursday 9-11	12.25	2.4	5.1	3.4	13		36.15	11.15	61		18.1	31.75	122	158.15
Friday 10-11	8.8	3.5	3	2.05	20	4.4	41.75	29.6	49.25		14.05	10.65	103.55	145.3
Monday 13-11	15.55	3.25	2.3	3.15	20	2.15	46.4		29.55		16.85	11.95	58.35	104.75
Wednesday 15-11	19.05	2.8	3.2	0.5	15	1.95	42.5		26	6.15	18	13.7	63.85	106.35
Thursday 16-11	11.55	1.85	4.15	4.2	9	2.8	33.55	7.3	64.15		18.1	26.75	116.3	149.85
Friday 17-11	13.8	2.7	3.35	3.6	16	1.05	40.5	21.15	47.35		17.1	18.2	103.8	144.3
Monday 20-11	16.9	3.2	1.95	4.1	18		44.15	5	32.35		12.85	8.05	58.25	102.4
Tuesday 21-11	11.45		2.85	1.5	20	5.05	40.85	8.7	28.5		21.4	16.75	75.35	116.2
Wednesday 22-11	14.35	1	1.95	5.15	11		33.45	5.1	30.1		17.3	16.15	68.65	102.1
Thursday 23-11	16.55		2.2	2.95	20		41.7	9.65	60.9		19.6	17.3	107.45	149.15