“IMPLEMENTING THE WASTE HIERARCHY”-ASSESSING RECYCLING POTENTIAL OF RESTAURANT WASTE

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ABSTRACT

Long working hours, the growing middle class, the increased participation of women in the labour force as well as the convenience offered by restaurants have greatly accelerated the growth of the commercial food service sector across the world (Elmedulan *et al.,* 2014). This is also true for South Africa where eating outside of the home has become more prevalent. South African food consumption patterns show an increase in the consumption of food away from home while consumption of home cooked meals is decreasing (Blick *et al*., 2018). The expansion of the commercial food service sector comes with an increase in the amount of waste generated by the sector, adding to the high volumes of waste that municipalities are grappling with. Municipal efforts towards diversion of waste from landfill tend to focus more on household waste, while waste coming from restaurants receives less attention. As a result, most of the waste generated in restaurants is disposed at the landfills as mixed waste.

The aim of this study was to assess the potential for diversion of restaurant waste away from landfill. A waste characterization study of thirteen restaurants in two shopping malls located in the eThekwini Metropolitan Municipality was conducted. The results showed that more than 74% of waste generated by the sampled restaurants can be recovered through recycling (paper, plastics, glass and tins) and composting/anaerobic digestion (food waste), while all of the waste generated is currently being disposed as mixed waste

The composition of waste and current waste management practices by restaurants in both malls highlight the need for improved waste management practices. These may include improved waste management practices at the point of generation, which appreciate waste as a resource and encourage diversion of waste away from landfill. The results also indicate a need for a more holistic approach to integrated waste management by municipalities that does not only focus on waste generated by households, but also address the contributions of commercial and institutional waste, which includes restaurants as source of waste with high recyclability potential.

KEYWORDS

Restaurant waste, waste characterization, packaging waste, food waste, mainline recyclables, recovery rate, waste diversion

INTRODUCTION

The hospitality sector in many parts of the world is expected to see significant rates of growth (Pirani and Arafat, 2014). This is also true for South Africa where eating outside of the home has become more prevalent. The rising popularity of eating out among South Africans is evident from the food consumption patterns which show an increase in the consumption of food away from home, while consumption of home cooked meals is decreasing (Blick *et al.*, 2018). Conducting a study on fast-food consumption among 655 17-year-olds in South Africa, Feeley *et al*., (2009) revealed that more than 80% of the participants of their study consumed fast food once a week. In 2011, almost three out of four South Africans from the age 16 years and older (25.3 million) consumed fast food in a period of four weeks (Analytix Business Intelligence, 2012). Projections show that the South African food service sector will see significant growth between the year 2015 and 2018 (BMI, 2015). The growth of the commercial service sector is driven by a number of factors including long working hours, the growing middle class, the increased participation of women in the labour force as well as the convenience offered by restaurants (Elmedulan *et al*., 2014). Convenience offered by restaurants includes speed, longer operating hours, delivery options and convenience such as drive-through facilities. The expansion of the food service sector consequently comes with an increase in the amount of waste generated by the sector, adding to the high volumes of waste that municipalities are grappling with.

Waste generation and disposal is one of the most visible and obvious consequences of restaurant operations (Pirani and Arafat, 2014). Researchers in the hospitality industry have explored “environmentally friendly” or “green practices” in the restaurant industry from different standpoints (Choi and Parsa, 2007; Ismail *et al*., 2010; Jang *et al*., 2011; Chou *et al*., 2012 Tibon, 2012; Wang, 2012; Kasim and Ismial, 2012; DiPietro *et al*., 2013; Wang *et al*., 2013; Hilario, 2014; Jang *et al*., 2015; Chen *et al*., 2015; Kwok *et al.,* 2016; Tan *et al*., 2017). Kwok *et al.,* (2016) looked at the green practices of restaurants with the aim of identifying the important attributes of green practice from a consumer perspective and also to understand how these attributes influence the consumer’s behavioural intensions. Wang (2013) explored the importance and the impacts of green practices in a restaurant. Hilario (2014) investigated responsiveness of fast-food chain managers towards the implementation of green practices in restaurants. However, there has been limited research specifically looking at waste management. This topic tends to be overlooked in the hospitality literature (Pirani and Arafat, 2014) and is usually submerged in the literature discussing environmental management (including all aspects of the environment such as water and energy use) and often does not concentrate much on the waste management aspect of the environment.

It is assumed that the food service sector generates a significant amount of packaging, organic food waste and waste cooking oil. Unfortunately, most of the waste produced in the restaurants is disposed at the landfills as mixed waste which consequently imposes pressure on the landfills. Also, when disposed, food waste decomposes and releases methane, a greenhouse gas that contributes to climate change (Visse, 2004). Despite the reported high recyclability of waste generated by the commercial food service sector, municipal efforts towards diversion of waste from the landfill tend to focus more on household waste while neglecting the relative small, but growing amount coming from restaurants (Tatano *et al*., 2017). According to Tatano *et al*., (2017), a comprehensive perspective of sustainable and integrated management should consider all waste, not only limited to the majority that is generated by households but also considering the non-negligible contributions of commercial and institutional waste, which includes restaurants as a significant waste generation source.

This study therefore aims to assess the potential for diversion of restaurant waste away from landfill.

MATERIAL AND MATERIALS

Sampling method

A purposive sampling method was used to select the participants of the study. Twenty restaurants were recruited to participate in the study (ten restaurants each from two shopping malls). Sampling of waste was carried out twice in each restaurant, once during a week day (Tuesday) and once during a weekend day (Saturday). To fully participate in the study, the restaurants were required to use coded bright green plastic bags (to distinguish the sample bags from the usual bags used) for the collection of waste during both sampling days (week and weekend day). Restaurants that did not participate on both sampling days were excluded from the waste characterization study. From the twenty restaurants, at least thirteen restaurants fully participated (six in Mall1 and seven in Mall2). The restaurants included cafes, fast food restaurants and full service restaurants. The different types of restaurants were included to ensure relevance to the restaurant industry, given that waste generated is influenced by the type of a restaurant.

Collection of waste and sorting

Site visits to both the malls and to the restaurants prior to the waste characterization study were done to familiarize the researcher with the waste flows from the restaurants to the waste areas of the mall. This allowed the researchers to gather information and also to design potential ways for collecting the waste sample in a manner that did not disrupt the operations of the mall and restaurants. The proposed plan of sample collection was to isolate waste arising from the sampled restaurants from waste coming from other shops (therefore the coded bright green bags) and also to isolate waste from each restaurant among sampled restaurants. This was done by assigning unique codes to the sampled restaurants. Green plastic bags marked with respective unique codes were distributed to the restaurants to use as bin liners a day before waste sampling day. It was then explained to the restaurant managers when to use the plastic bags. On the sampling day, the restaurants were revisited before they opened to check if the plastic bags were placed in the bins and also to check if there was no waste that was left over from the previous day so as to ensure that only waste accumulated on the sampling day was captured. Waste accumulated on the sampling day was then collected to the waste area as usual, where the green bags were separated from black and clear plastic bags that are normally used by shops. Green plastic bags were further grouped under similar codes (multiple bags from the same restaurant) and those plastic bags that were not used by restaurants were later requested back to ensure that there was no green bag missing. In the waste areas of the mall, the plastic bags from each restaurant were counted and weighted with a calibrated digital scale with an accuracy of two decimal places. Each bag was then opened and the content deposited on to a sorting table and waste was then separated into 21 predetermined waste categories. However, during presentation of the results only the nine main categories (glass, porcelain, paper and cardboard, non-recyclable material, metal, plastic, food waste, hazardous waste and other) were regarded sufficient to

address the aim of the study in terms of assessing recycling potential of restaurant waste, which is in line with Chang and Davila's (2008) assertion that classification of the waste categories depends on the purpose of its application. Waste characterization was carried out at the central waste area of the mall and personal protective equipment (dust masks, hats, steel toe boots, overalls and gloves) was worn at all times. To provide guidance and to ensure consistency in the sorting procedure in both malls, waste categories shown in Table 1 were used during sorting. The waste categories covered waste material that is likely to be generated in restaurants. These included mostly packaging waste from transport packaging, packaging of ingredients and sales packaging of products (glass, cardboard, metals, and plastic), food waste (inedible food waste generated during preparation, food left on a customer's plate), broken porcelain, fused fluorescent light bulbs (hazardous waste) and "other" waste to provide a category for waste not catered for elsewhere.

Table 1: Waste categories used when sorting

General waste Categories	**Fractions/Description**
Glass	Glass bottles, glass cups etc.
Porcelain	
Paper and Cardboard- All recyclable Paper and Cardboard	All white Office Paper
	Common mix paper
	Cardboard
	Tetra Pak
Non-recyclable paper	Badly soiled, tissue paper, wax paper, laminated etc.
Metal: ferrous and non-ferrous	Ferrous metals: metal cutlery
	Non-Ferrous metals : beverage or coke can, tin foil etc.
Plastic- All recyclable plastics	HDPE drink bottles – i.e. Milk bottles
	PET drink bottles – i.e. 2 litre or 1 litre beverage bottles
	Polypropylene – i.e. PET bottle caps etc.
	Polystyrene
	LD - Clear Plastic
	LD - Mix Plastic
	LD - Stretch i.e. cling wrap
	All non-recyclable or not identified plastics
Food waste	Avoidable food waste- burnt food, leftover food etc.
	Un-avoidable food waste-bones, peels, egg shells etc.
Hazardous waste	Cleaning chemicals/ medical care waste, fluorescent light bulbs
Other	

To determine waste composition of the sampled restaurants, a total of **799.35kg** of waste from two malls was sorted and the weight of each waste category was recorded. As indicated earlier sampling was carried out twice in each restaurant, once during a week day and once during a

weekend day. Waste produced on the sampling days were accumulated and sorted the following day similar to the procedure outlined in Dahlen and Lagerkvist's (2008) time limitation procedure. Dahlen and Lagerkvist' (2008) report that a waste sample should be sorted within two days of collection to avoid physical and chemical changes to the sample. In Mall1 135.10kg of waste was sorted for a week day sample and 252.95kg for a weekend sample while 148.05kg for a weekday sample and 263.25kg for a weekend sample was sorted in Mall2. The total waste available for sorting into fractions during the week in both malls was comparably smaller than the total waste available for sorting during the weekend, suggesting that restaurants generate more waste during the weekend than during the week. Table 1 shows total kilograms of waste sorted from different types of restaurants in Mall1 and Mall2.

Table 2: Kilograms of waste sorted from different types of restaurants

Mall	**Restaurant type**	**Number of Restaurants**	**Total waste sorted (Kg) week sample**	**Total waste sorted (%) week sample**	**Total waste sorted (Kg) weekend sample**	**Total waste sorted (%) weekend sample**
Mall1	Fast food Restaurant	1	15.50	5.47	19.60	3.80
Mall1	Full service Restaurant	5	119.60	42.24	233.35	45.21
Mall2	Café	3	22.55	7.96	69.50	13.46
Mall2	Fast food Restaurant	2	17.05	6.02	26.70	5.17
Mall2	Full service Restaurant	2	108.45	38.30	167.05	32.36
Grand Total		**13**	**283.15**	**100**	**516.20**	**100**

RESULTS AND DISCUSSION

Overall waste composition of restaurants was derived from combining waste sorted during the week and waste sorted during the weekend from each restaurant. Due to the small sample size, average of each fraction from all the restaurants was then calculated to get an objective view of the general composition of the waste as percentages by weight. Figure 1 shows the waste composition of Mall1 when waste sorted during the week and weekend is combined.

From Figure 1, it is clear that food waste is the major fraction (by weight) generated by restaurants in Mall 1, accounting for 47.74% of the total waste from the sampled restaurants. Similarly, food waste was also the highest waste category (by weight) in Mall2, contributing about 49.66% of the total waste sorted (see Figure 2). These findings are consistent with

previous studies where food waste formed the bulk of waste generated in restaurants (Hogan *et al*., 2004; Majid and Hwee, 2007; Tatano *et al*., 2017). The percentages of the food waste component from the above cited studies ranged from 36.81% to 71.73%. When conducting a study in three restaurants (full service restaurant, a restaurant located in a shopping centre and a canteen) in the Republic of Ireland, Europe, Hogan *et al.,* (2004) reported 36.81% of food waste. Tatano *et al.,* (2017) found 28.2% of food waste when they conducted their study in a fast casual restaurant in Italy, while Majid and Hwee (2007) found an alarming 71.73% of food waste when they conducted a waste characterization study in 10 restaurants with size ranging from seven to sixty tables in Malysia. Comparison of the food waste component with other restaurant waste characterization studies such as those of Dangi *et al.,* (2011), Alfagi *et al.,* (2015) and Oliveira *et al.,* (2016) was not possible due to different terminology or rather categorization of the food component. Unlike Majid and Hwee (2007) who fractionated the organic component into food and garden waste, those studies only had organic waste as one category, with no clear definition of what it means. In this regard, it was not possible to compare the food waste component to those studies as it was not clear as to whether the organic waste category contained only food waste or all waste materials that fall into the organic waste category such as wood waste, garden waste and food waste. Dahlen and Lagerkvist (2008) criticize the use of the term “organic waste” and reports that the use of the term as used by these authors is wrong as it is used to classify only food waste and garden waste and yet there are other organic waste materials such as paper. Derqui *et al.,* (2016) and Lebersorger and Schneider (2011) also indicate that different classification methods make comparing findings difficult. Lebersorger and Schneider (2011) point out that a lack of substantial information including the definition of food waste categories, the exact classification of individual food items and the consideration of food packaging as reasons for incomparable data. The different methodology or classification of food waste clearly illustrates a challenge in terms of comparing and applying data and in turn highlights the need for a uniform method of classifying food waste in order to produce data that can be compared and applied. Oelofse *et al*., (2016) recommend accurate and detailed recording of the sampling methodology.

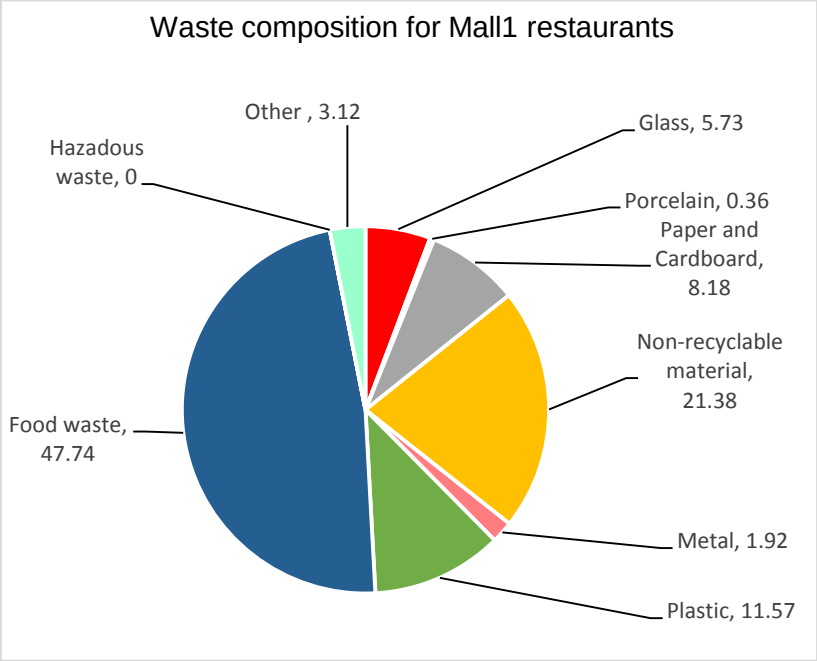

Figure 1*:* Waste percentage composition for mall1 restaurants

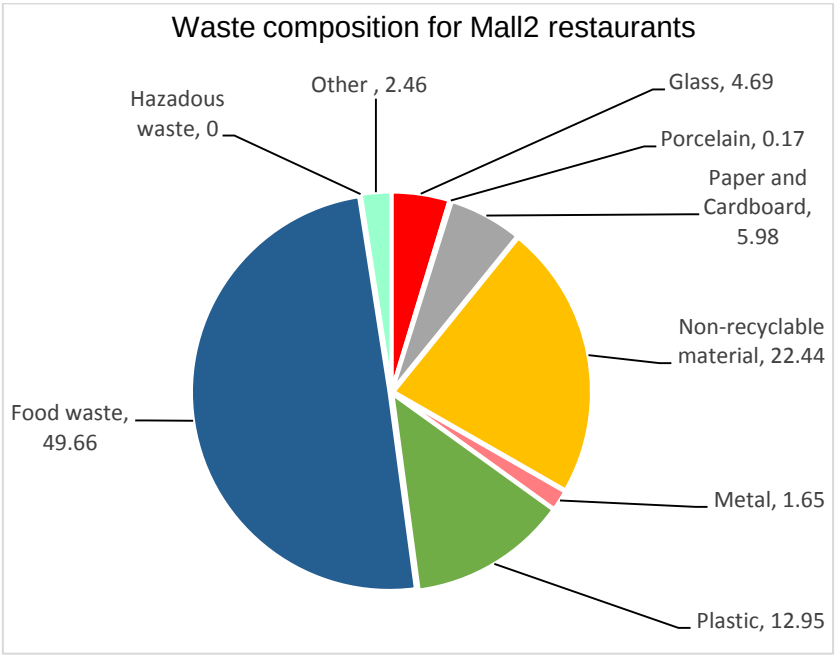

Figure 2: Waste percentage composition for mall2 restaurants

In contrast to the findings of restaurant waste composition presented in Figure 1 and 2, a waste characterization study by Austin Resource Recovery (2012) found cardboard as the greatest quantity of waste contributing 26% of the total waste generated in quick service (also known as fast food) restaurants. Although the high amount of cardboard as compared to food waste in the Austin Resource Recovery's (2012) study may have resulted from various factors including efficient staff members, restaurant practices and policies, proper food stock management, menu style as well as type of restaurant, it is not unexpected that quick service restaurants may produce more cardboard than food waste when measured by weight. Generally, quick service restaurants are characterized by limited menu options, provision of standardized ingredients, partially prepared food, limited seats and food prepared for take away (Austin Resource Recovery, 2012). Standardizing and limiting menu items reduces food waste generated during preparation stages (Tatano *et al*., 2017) while plate waste and packaging waste may be reduced by the take away type of service where the food and its packaging is taken away and disposed out of the premises of the restaurant (Aarnio and Hamalainen, 2008). Another possible explanation to differences between the findings presented in Figure 1 and 2 and those of Austin Resource Recovery (2012) could be the fact that Mall1 and Mall2 have cages for source separation of corrugated cardboard (see Figure 3) while the study only included waste destined for disposal. As a result, most of the cardboard that was found during sorting was food contact cardboard packaging (see Figure 3).

Figure 3: Shows contaminated food contact cardboard packaging (left) found during sorting and clean source separated corrugated cardboard (right)

The second predominant waste material found in both Mall1 and Mall2 was non-recyclable material. Non-recyclable material consisted of non-recyclable paper (mostly food soiled tissue paper), non-recyclable plastic and other single use non-recyclable beverage containers such as coffee cups. The amount of non-recyclable material found in Mall1 and Mall2 was almost the same with 21.38% of the total sorted in Mall1 and 22.44% in Mall2. The considerable amount of non-recyclable waste can be attributed to the utilization of single use paper napkins in the kitchens, tissues, individual condiment packets and other food packaging plastic that falls under the non-recyclable waste category.

In Mall1 non-recycle material was followed by plastic (11.57%), paper and cardboard (8.18%), glass (5.73%), other material (3.12%), metal (1.92%), porcelain (0.36%) respectively. Similarly, non-recyclable waste in Mall2 was followed by plastic (12.95), paper and cardboard (5.98%), glass (4.69%), other material (2.46%), metal (1.65%) and porcelain (0.17%). In contrary to the composition of mainline recyclables (paper and cardboard, glass and metal) found in Mall1 and 2 (see Figure 6), most of the studies found paper and cardboard to be the largest packaging components (Majid and Hwee, 2007; VanWaning, 2010 cited in Pirani and Arafat, 2014; and Davies and Konisky, 2004) while Tatano *et al.,* (2017) found glass as the largest component. This may be attributed to the source separation of corrugated cardboards as indicated earlier. There was no hazardous waste found in both Mall1 and Mall2 which concurs with other studies (Dangi *et al*., 2011; Austin Resource Recovery, 2012). In total, the mainline recyclable material including plastic, paper and cardboard, glass, and metal presented 27.40% in Mall1 and 25.27% in Mall2. These figures suggest a greater potential for recovery through recycling. The considerable amount of mainline recyclables found in both

malls appear to be close to the total percentages of recyclable material found by Majid and Hwee (2007) at 21.5%.

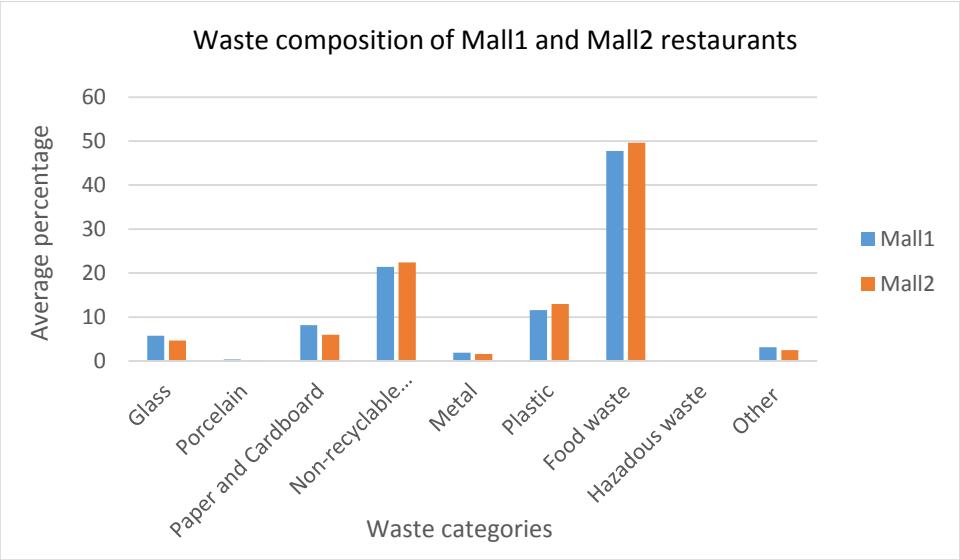

Figure 4: Waste percentage composition for Mall1 and Mall2 restaurants

A closer consideration of waste composition by type of restaurant is represented in Figure 5 and 6. As expected, waste generated by Mall1 restaurants was dominated by food waste (see Figure 5). Surprisingly, the fast food restaurant contributed more food waste (51.37%) than the full service restaurants (47.39%). Higher food waste percentage in a fast food restaurant when compared to full-service restaurants was unexpected given that fast food restaurants are characterized by limited menu options, provision of standardized ingredients, partially prepared food, limited seats and food prepared for take away while full service restaurants offer a variety of meals that are eaten in the premises of the restaurants. This finding is contradictory to Silvennoinen's *et al*. (2012) study which showed that full restaurants waste more food waste than fast food restaurants. Fast food restaurants discarded about 7% of all food served while full service restaurant contributed 19% of all food served. However, the amount of food waste found in fast food restaurants confirms a finding by Kuczeruk (2011) in Elmedulan (2014) who found that food waste contributed more than 50% of waste coming from fast food restaurants. Plastic was the second predominant waste category in fast food restaurant at 23.31% while 10.41% of plastic was found in full service restaurants making non-recyclable material the second predominant waste stream in full service restaurants. Low levels of metal and other waste categories were present in both fast food and full service restaurants. Glass material was absent in fast food restaurant while 6.29 % of glass was found in full service restaurants. Kuczeruk (2011) in Elmedulan (2014) also found minimal amounts of glass in a fast food restaurant at 0.6%.

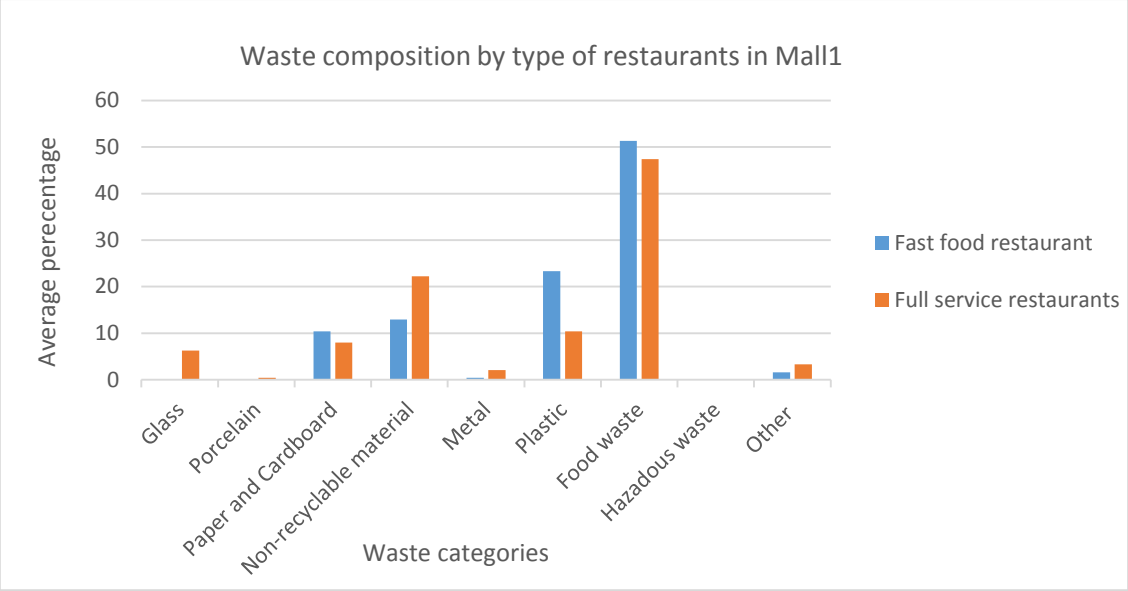

Figure 5: Waste composition by type of restaurant in Mall1

As expected, food waste contributed the most in all types of restaurants in Mall2. Comparatively fast food restaurants had the highest food waste percentage (57.49%) than full service restaurants (48.97%) and cafes (47.47%). This finding contradicts the finding of Silvennoinen *et al*., (2012) who found food waste by type of restaurant as follows: cafes (19%), full service restaurants (18%) and fast food restaurants (7%). Although the estimated food waste by type of restaurant found in this study does not concur with Silvennoinen's *et al*., (2012) finding, it is interesting to note that food waste percentage found in cafes and full service restaurants was almost the same in both studies. Non-recyclable waste also seemed to make a considerable contribution in all types of restaurants in Mall2 forming the second predominant waste category. The amount of non-recyclable waste was almost the same in full-service restaurants and cafes at 23.72% and 22.27% respectively, while the fast food restaurant contributed 14.17% of the total amount of waste. This indicates a need for restaurants to use re-usable utensils and products packaged in recyclable material. Pirani and Arafat (2014) suggested green purchasing as one of the strategies that can be used to reduce waste in the restaurant hence green products often result to reduced waste generation as they are not packaging-intensive and the packaging that they do have is recyclable. Demand for recyclable and re-usable utensils will not only result in improved waste management in the restaurants but will also result in a shift towards production of re-usable and recyclable material from their suppliers. Davies and Konisky (2000) report that while it is important for restaurants to reduce their direct environmental impacts including energy use, an opportunity to also improve upstream environmental impacts exists. They report that the restaurants are the ones that make a decision about what to sell to the customers as well as where to source the ingredients and so they have the authority to expand the decision to include environmental aspect such as use of recyclable packaging in their products and use of organic ingredients. Conducting a study on food waste in the food service, Derqui *et al*. (2016) also touched on the need for restaurants to put pressure on their suppliers to adopt environmentally sustainable practices in order for them to operate in a sustainable manner. Plastic waste also formed a considerable fraction of the total waste. The percentage of plastic was high in cafes and almost the same in fast food restaurants and full service restaurants. Plastic material in a restaurant comes from packaging for ingredients that are used to prepare meals, PET and plastic cups

to serve beverages as well as disposable cutlery for takeaways. Low levels of metal were found in all the types of restaurants, presenting less than 2% of the total waste. Previous research on restaurant waste has shown metal to contribute less than 9% of the total waste (Hogan *et al*., 2000; Majid and Hwee, 2007; Dangi *et al*., 2011; Austin Resource Recovery, 2012; Tatano et al., 2017; Oliveira *et al*., undated). Full service restaurants had the highest percentage of glass in Mall2 while only 0.65% of glass was found in cafes. Absence of glass in a fast food restaurant could be explained by the fact that fast food restaurants only serve non-alcoholic beverages in tins, plastic bottles and paper cups. On the other hand, depending on the restaurant, full service restaurants also serve alcoholic beverages in bottles. This finding concurs with Austin Resource Recovery's (2012) finding where there was no glass material found when they conducted a waste characterization in a fast food restaurant.

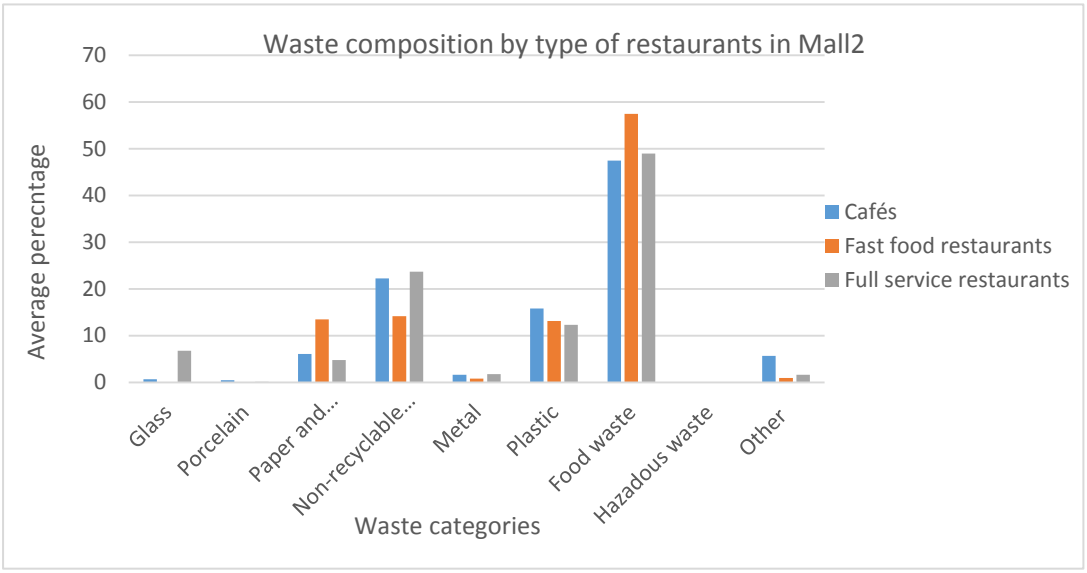

Figure 6: Waste composition by type of restaurant in Mall 2

Through the waste characterization it was possible to calculate theoretical recovery potential of the waste generated by the restaurants. This was done by adding the waste composition percentages of the mainline recyclable material (paper, plastics, glass and tins) and food waste. Overall potential recovery rate in Mall1 was found to be 75.14% and 74.93% in Mall2. In parallel with the potential recovery rate of Mall1 and Mall2, potential recycling rate by restaurant is represented in Figure 7 and 8. The results showed that most of waste generated in the restaurants could be recycled. This finding indeed confirms previous research which also found that most of the waste generated in restaurants can be recovered through composting of food waste and recycling of recyclable material (plastic, glass, metal, paper and cardboard) Nielsen (2004) in Kasim and Ismail 2012; Majid and Hwee, 2007; Austin Resource Recovery, 2012). Comparatively, the fast food restaurant had the highest recycling potential rate (85.47%) than full service restaurants (74.12%) in Mall1. The highest recycling potential rate in Mall2 was found in fast food restaurants (82.92%) followed by full service restaurants (74.54%) and cafes (71.65%). The theoretical recovery potential of waste generated by Mall1 and Mall2 restaurants is less than the 95% potential recycling rate reported by Nielsen (2004) in Kasim and Ismail (2012). Currently, waste from restaurants is handled by the same service provider contracted by the management of both shopping malls. Unsorted waste from the

restaurants is collected and sorted for recycling while residual waste is taken for landfilling. Waste source separation in the restaurants could assist in ensuring recovery of clean recyclables.

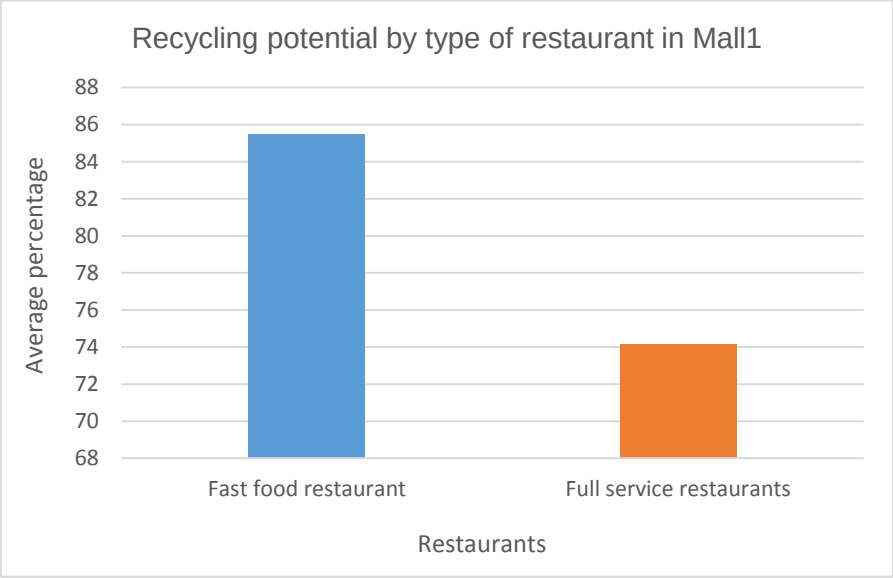

Figure 7: Recycling potential rate by type of restaurant in Mall1

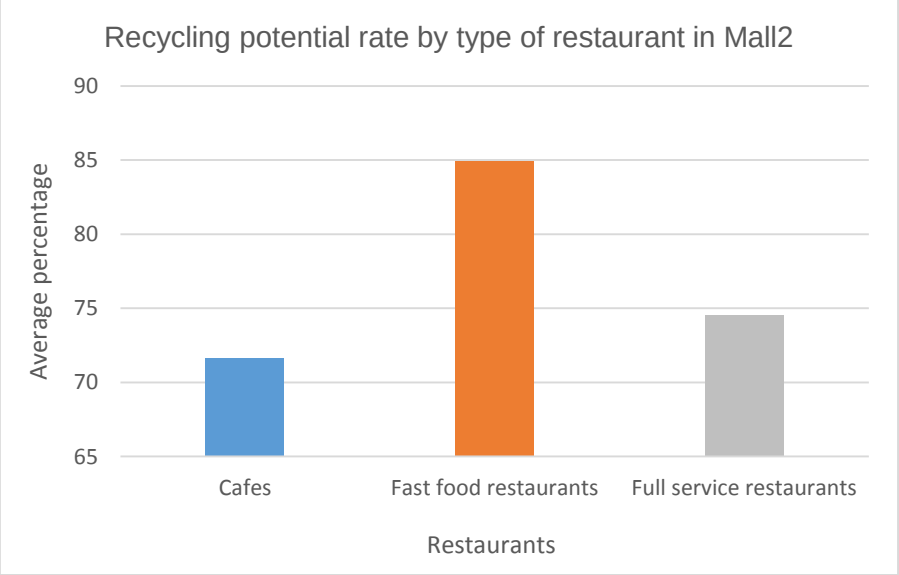

Figure 8: Recycling potential by type of restaurant in Mall2

CONCLUSION AND RECOMMENDATIONS

The aim of this study was to assess the potential for diversion of restaurant waste away from landfill. Waste characterization studies in Mall1 and Mall2 revealed that more than 74% of waste generated by the sampled restaurants has the potential to be diverted from landfill through recycling (this includes paper, plastics, glass and tins) and composting/anaerobic digestion (food waste), while all of the waste generated is currently being disposed as mixed waste. Potential recycling rate by type of restaurant in Mall1 ranged from 74.12% to 85.47% and 71.65% to 84.92% for Mall2. Food waste accounted for close to 50% of waste that was sorted in both Mall1 and Mall2. These figures demonstrate how significant food waste is as a component of the restaurant waste and also highlights need for diversion of waste through composting or anaerobic digestion. Also, South Africa is considering a landfill ban on disposal of organic waste (DEA, 2013), therefore it is crucial for restaurants to develop or improve organic waste management programs ahead of the organic disposal ban. When combined, mainline recyclables, presented 27.40% in Mall1 and 25.27% in Mall2, suggesting a greater potential for recovery through recycling. Another notable observation in the study was the considerable amount of non-recyclable waste owing to the use of single use of paper napkins, non-recyclable food packaging, waxed disposable cups and other single use materials. With the expected growth in the restaurant industry, improved waste management practices at the source of generation, which appreciate waste as a resource and encourage diversion of waste away from landfill is required. This may include implementation of source separation schemes to enhance recycling and ensure diversion of clean recyclables as suggested above. Waste prevention and reduction through reducing material wastage and green purchasing should be given greater priority as dictated by the waste hierarchy. Possible waste minimization options for each waste fraction was sourced from the literature and are provided in table 3. More research, however, needs to be done to understand sources, causes and drivers of waste generation in the restaurants. Also, as indicated above a uniform method of classifying food waste is recommended in order to produce data that can be compared and applied.

Table 3: Possible waste minimization options of each waste fraction

General waste Categories	Fractions/Description	Waste minimization options of each waste fraction	References
Glass	Glass bottles, glass cups etc.	• Using dispensers and re-usable glasses for beverages in full service restaurants	Wrap, undated
Porcelain		• Providing training to the staff members	Pirani and Arafat, 2014
Paper and Cardboard-All recyclable Paper and Cardboard	All white Office Paper	• Printing and copying double sided • Source separation and segregation of white office paper which cannot be avoided	Pirani and Arafat, 2014

	Common mix	• Printing and copying double sided	Singh *et al*. 2014
	Cardboard	• Encouraging the suppliers to use re-usable totes and crates for transportation of ingredients	Verghese *et al*., 2015; Singh *et al*. 2014; United States Environmental Protection Agency, 2014
	Tetra Pak	• Buying in bulk containers	United States Environmental Protection Agency, 2014
Non-recyclable paper	Badly soiled, tissue paper, wax paper, laminated etc.	• Using products that come in less packaging, and also more recyclable packaging	Singh *et al*. 2014
Metal: ferrous and non-ferrous	Ferrous metals: metal cutlery	• Using dispensers and re-usable glasses for beverages in full service restaurants	Wrap, undated
	Non-Ferrous metals : beverage or coke can, tin foil etc.	• Donating old kitchen utensils/table ware	Singh *et al*., 2014
Plastic- All recyclable plastics	HDPE drink bottles – i.e. Milk bottles	• Buying HDPE packaged food in larger bulk packaging	United States Environmental Protection Agency, 2014; Singh *et al*., 2014
	PET drink bottles – i.e. 2 litre or 1 litre beverage bottles	• Using dispensers and re-usable glasses for beverages in full service restaurants • Buying in bulk	Wrap, undated; Singh *et al*., 2014
	Polypropylene – i.e. PET bottle caps etc.	• Using dispensers and re-usable glasses for beverages • Buying in bulk	Singh *et al*., 2014; Wrap, undated
	Polystyrene	• Avoiding over packaged products	Singh *et al*., 2014; United States Environmental Protection Agency, 2014
	LD - Clear Plastic	• Avoiding over packaged products	Singh *et al*., 2014; United States Environmental Protection Agency, 2014

	LD - Mix Plastic	• Avoiding over packaged products	Singh *et al*., 2014; United States Environmental Protection Agency, 2014
	LD - Stretch i.e. cling wrap	• Avoiding over packaged products	Singh *et al*., 2014; United States Environmental Protection Agency, 2014
	All non-recyclable or not identified plastics	• Purchase of products with recyclable packaging • Using dispensers or refillable containers for condiments • Preventing the use of straws • Use condiment dispensers instead of individual packets	Pirani and Arafat, 2014; United States Environmental Protection Agency, 2014
Food waste	Avoidable food waste-burnt food, leftover food etc.	• Accurate customer demand forecasting • Staff training • Incentivising staff members for reducing food waste • Careful menu planning • Encouraging customer to take doggy bags • Storing food properly • Donating leftover food • Educating customers about food waste	Silvennoinen *et al*., 2012; Pirani and Arafat, 2016; Betz *et al*., 2015;United States Environmental Protection Agency, 2014
	Un-avoidable food waste-bones, peels, egg shells etc.	• Buying ready to cook food	Tatano *et al.,* 2017

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