WASTE COMPOSITIONAL ANALYSIS OF AG. NIKOLAOS IN THE MUNICIPALITY OF LARNAKA, BASED ON THE IMPLEMENTATION OF THE EUROPEAN PROGRAM PAY AS YOU THROW (PAYT)

PAYT – TOOL TO REDUSE WASTE IN SOUTH EUROPE

LIFE15 ENV/PT/000609

WASTE CHARACTERIZATION CAMPAIGNS AT SITE LA1 – C1

Abstract

Today's cities are characterized essentially by a linear metabolism, where the consumers are producing, consuming and discarding their waste. This is something that is characterized as a non-sustainable practice. The consumption of resources, materials and the waste generated as a result are growing exponentially and this is something that makes the waste management procedure very difficult. Unfortunately non-rational waste management results in the contamination of soil, water, and the atmosphere. The result is a significant, negative impact on public health.

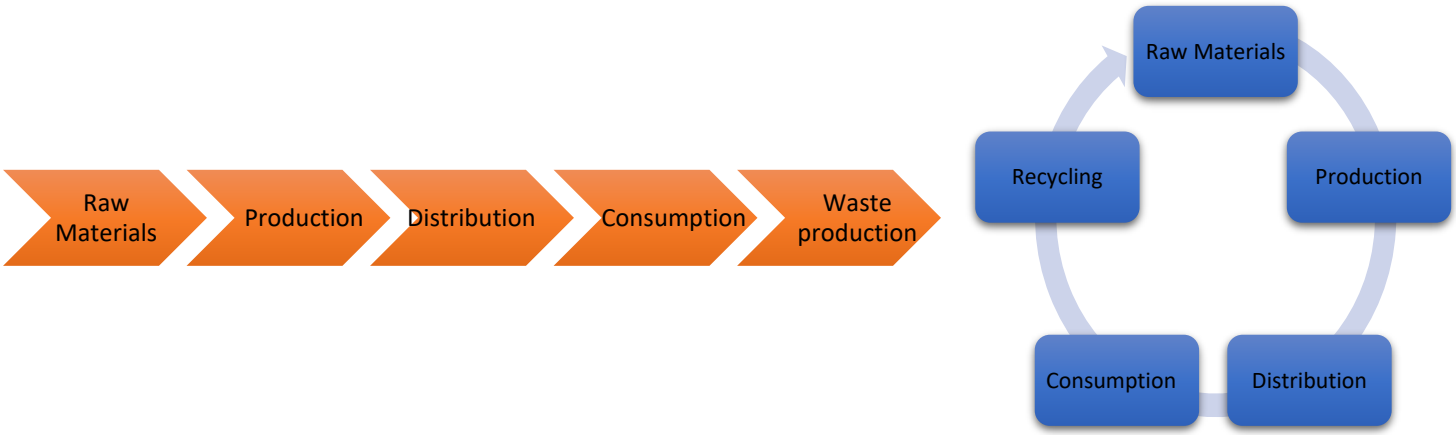


Chart 1: a) Linear economy model b) circular economy model

1. Introduction

The “Pay As you Throw” program is part of the transition from the linear economy to the circular economy that requires the reuse, recycling and recovery of waste, by turning them back into raw material.

Nowadays, urban areas must be seen as a driving force in reducing environmental impacts and facilitating adaptation to the objectives set out by the EU regarding the pillars of sustainability (environment, economy and society). Based on directive 851/2018 of the European Parliament, and the Council that took part on the 30th of May 2018, in order to achieve the objectives and a transition to a European circular economy with a high level of resource efficiency, member states of the EU must follow the necessary measures to ensure that, by 2025, the preparation for reuse and recycling of waste from urban areas is achieved.

The EU's 2025 overriding objectives in the recycling of Municipal Solid Waste (MSW), are to achieve a recycling rate of 55% by 2025 (up from the 44% that is stated today), a recycling rate of 60% by 2030, and a 65% recycling rate by 2035.

In addition, by 2021 they have set the target of 40% for the separate collection of waste from the percentage of total solid municipal waste, with this percentage increasing to 50% by 2027.

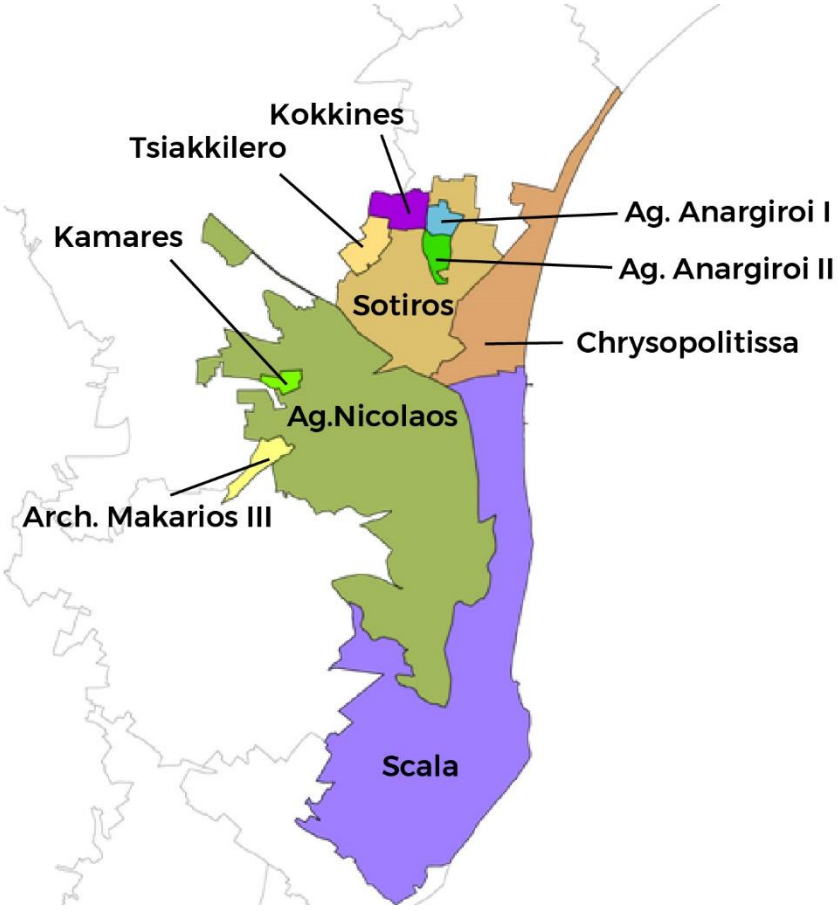
The revised directive (EU) 2018/851 stipulates that the gradual reduction of landfill is vital for the prevention of harmful effects impacting on both human health and the environment through the correct management of waste based on their assortment as defined by directive 2008/98/EC.

Households are the main source of MSW, followed close behind by commonly found establishments such as small businesses and public institutions. Through Eurostat's trusted information, MSW consists mainly of paper products, plastic, glass, metals, and food waste (Montanez et al., 2019).

In order for such a program to be successfully completed, the local government and the competent authorities responsible for decision making must be aware of what kind of waste the consumer most often produces. The waste composition analysis aims to create a synthesis data set regarding the type of waste produced with the goal of providing crucial information relating to the subject. It provides important information on the type of waste that is discarded, the consumption habits of citizens while at the same time being an important factor in deciding how to manage the waste in order to reduce the environmental effects (Zorpas and Lazaridi, 2013). Therefore, it provides the composition data necessary for rational decision makers to select a waste treatment and disposal plan (Zorpas et al., 2015).

2. Area Description

The area under investigation is the parish of Ag. Nikolaos of Larnaka Municipality, which includes 16887 residents and is contained within an area of 1250 ha. It is considered the largest and most populous parish within the municipality (Map 1). The main features of this parish are residential and business properties. This is illustrated by a considerable range of small shops, businesses, dining areas, schools (primary, secondary), swimming pools, supermarkets, as well as the Larnaka Hospital. The parish of Ag. Nikolaos is inhabited mainly by Cypriot citizens (85%). The remainder of citizens in the region are largely those from European countries (15%) (Cyprus Statistical Service, 2015).



Map 1: Districts of the Larnaka Municipality

2.1 Municipal Waste Data

The collection of mix waste in the Municipality of Larnaka is performed by the Cleaning Department of the Municipality twice a week (door by door) and at the end, the waste is transported at the Koshis Municipal Waste Treatment Plan. The charge at the Koshis Station is about 44 €/t for the mix waste, 12 €/t for green waste, 16 €/t for bulky materials (furniture, equipment etc) and for the recyclable materials, there is no charge. The collection and management of recyclable materials is performed by the company Green Dot Cyprus (GDC) using a door-to-door collection method twice a week. In the Municipality of Larnaka during 2011, the total amount of mix waste was 33595,82t of MSW produced overall and at the end of 2017 was produced 33916,93t. In 2011, the management cost amounted to 2504278,45 € while management costs in 2017 were 2259862,93 €.

When it comes to the paper, glass and PMD recyclable materials that were collected in the years 2011 and 2017, these are compared in Diagram 1. The graphic illustrates the decrease in the recycling rate in regard to paper and PMD, while there has been a slight increase in glass recycling.

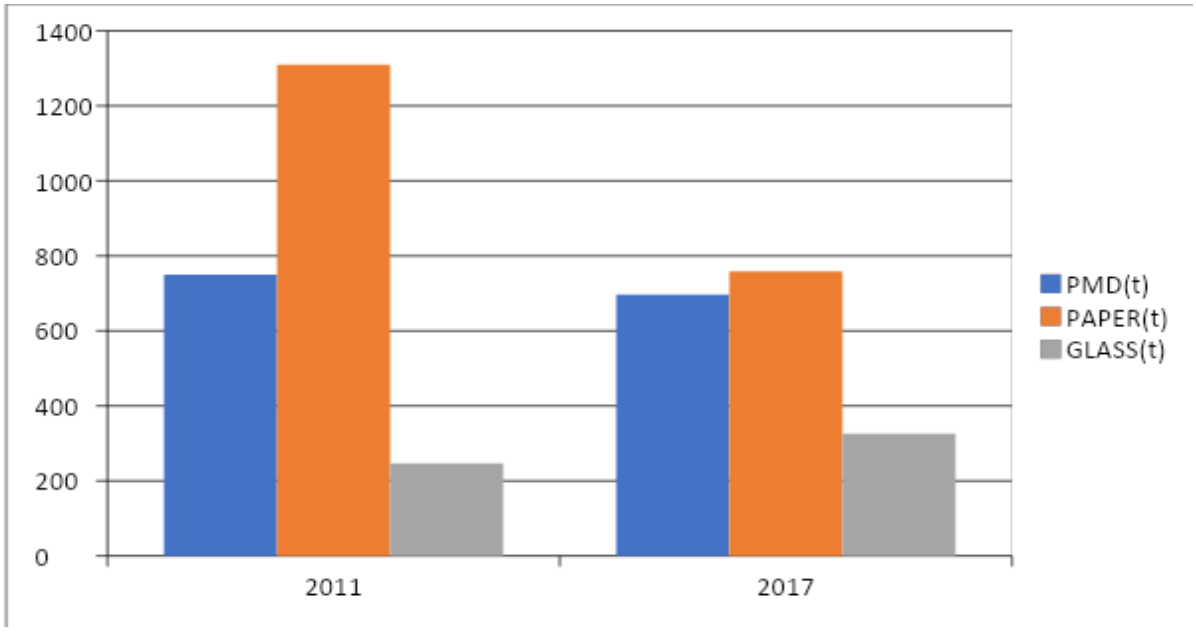


Diagram 1: Quantities collected in the year 2011 and 2017

3. Waste Compositional Analysis

3.1 Methodology

During the implementation of the waste composition analysis, samples were taken directly from the citizen's waste disposal and before the scheduled Municipality garbage to avoid their compression. This was performed for more efficient and reliable characterization of solid waste which was applied in Denmark in 3 of its Municipalities also (Aabenraa, Haderslev, Sonderborg) (Maklawe et al., 2015). For a uniform coverage of the area, the samples were collected from various locations.

The procedure for clarifying the composition of waste consisted of three stages:

1. Sampling of waste at source
2. Segmenting waste by material (e.g. paper, glass, food waste, etc.)
3. Data manipulation and interpretation

In total, 36 household plastic bags were collected for sampling from the entire main area. For the analysis of the composition of the waste produced, the household wastes were divided into 14 main categories and subcategories, which are presented in Table 1.

Following the manual sorting and segmenting of waste per segment, the storage bags were weighed with the precision scale. This was performed by weighing each bag separately per type of waste.

A screening process followed the collection of samples and this occurred on the same day that the waste was collected. This involved the citizens removing their trash, to avoid the humidity from the food in other materials and to avoid loss of mass. The time taken to do so has been shown to minimize the physical changes of samples and is recommended by the European Commission (2014).

By following this time-consuming procedure, the details were as precise as possible and are further explained below. Include very important information on national or regional waste statistics as a basis for assessing capacity for proper environmental management.

The data was collected and processed in the Excel Project Data Tool which can help local authorities understand the current situation with regard to the quantities of waste produced (World Bank, 2019).

3.2 Waste Compositional Analysis Categories

In Table 1, the segmented categories of materials are stated, this included 14 waste categories making facilitating grouping easier.

Table 1: Streams categories

Streams categories	
PMD	Plastic water bottles, plastic containers, metal packages (soft drinks, trays), juice/milk cartons, plastic soft drinks, PE (milk containers, detergents), PP (inner cereal packaging, biscuits), PS (egg bags, hamburger boxes), PVC (olive oil bottles), PIP, PET (beverage cans), not clarified
Plastic film	Nylon supermarket bags
Plastic Non-recyclable	
Aluminum	
Foil	
Aluminum Packaging	Packaging snacks, crisps
Paper	Packaging (wrapping paper, paper bag, corrugated board), newspaper, magazines, office, advertising, books, other
Glass	Bottles (white), bottles (green), other (broken)
Kitchen paper	
Toilet paper	
Food waste	Bakery, meat, dairy, fish, cooked, grape, banana

Non edible food waste	Bones, peels, shells, coffee scraps
Various	Toys, textiles, medicines, WEEE, batteries, cigarette butts, stationery, debris, stones, soil, aerozol

- The PMD category for plastic waste was separated by the resin type (Avella et al., 2001) (PET, HDPE, PIP, PP, PS, other resins), metallic packaging, juice boxes and plastic type-soft drinks.
- Paper was classified as stationery, magazines, books, office and packaging items, and various items such as paper towels, wrapping, toilet paper, and envelopes.
- Food waste included products intended for human consumption (e.g. fruit) and non-edible waste (eggshells, peels, coffee residues).
- The glass objects were separated based on the color of the material and where crushed.
- The category "other waste" consisted of items that did not belong to any of the aforementioned categories.

The method of compositional analysis of MSW is based on the ASTM DD5231-92/2003 "Standard Test Method for Determination of the Composition of unprocessed Solid Waste". The method of sampling in the final disposal was selected by simulating the Model of Uniform Random Sampling (Random Uniform Sampling) over a period of 2 months. The compositional analysis began in February and was completed in April. In total, samples from 36 different points were taken. Qualitative and quantitative analysis of the total weight (1381 kg) was performed 3 times per week. In Table 2 below, the areas from which the samples were taken are presented.

Table 2.1: Sampling point 1

Kg	**Sampling point**
25.5	Potamou Indou
95.5	Karyatidon
73.0	Chrysanthemon
59.9	Ioannis Makrigianni
52.0	Krinon
16.5	Vergina
62.0	Ipirou
32.0	Verias
40.0	Piraeus
15.0	Christoforou Savva
48.0	Souniou
57.0	Lavriou
24.5	Minotavrou
60.5	Tyrnavou
32.5	Karpenisiou
6.0	Livadia
31.5	Kastalias
30.5	Menelaou
16.0	Ionias
26.0	Ag. Georgiou Makri
29.0	1st April
46.0	Sokratous
37.5	Artas
38.0	Tinou
27.0	Thessalonikis
61.0	Chloes
47.0	Eleftherias
50.5	Leonidou
25.5	Vasileos Konstantinou

15.5	Vasileos Othonos
7	Einstein
41.5	Egyptou
59.0	Kyklopon
60.0	Beethoven
33.0	Ag. Savva

Table 2.2: Sampling point 2

kg	**Sampling point**
35.0	Pandoras
34.0	Sopen
51.0	Nikolaou Mantzarou
33.5	Charalampou Patsidi
27.0	Ieronymou Varlaam
12.0	Pavlou Krinaiou
19.0	Irodou Attikou
53.0	Potamou Indou
22.5	Dimitriou Margariti
25.0	Archiepiskopou Paisiou
30.0	Mytilinis
28.0	Konstantinou Valsamaki
37.5	Christou Karatza
29.0	Mystra
12	Karyatidon
8	Konstantinoupoleos
13.0	Kosta Kariotaki
10.0	Thiatiron
5.0	Lamporou Katsoni
12.0	Solonos Frandoulide
13.0	Ioanni Kondylaki

7.0	Telamonos
11.0	Panidos
18.0	Ioanni Ntyna

4. Results

The analysis of the composition of the solid waste produced from the study area is describe in Diagram 2.

The main quantities of waste concerned avoidable food waste (18.54%) and 14.69% products that could be used for composting (green waste, peel). Other quantities included 13.47% paper, non-avoidable food waste (9.77%), 9.59% “other waste”, 9.12% PMD, 7.53% glass, 1.55% plastic films, 1.38% plastics non-recyclable and 1.19% aluminum.

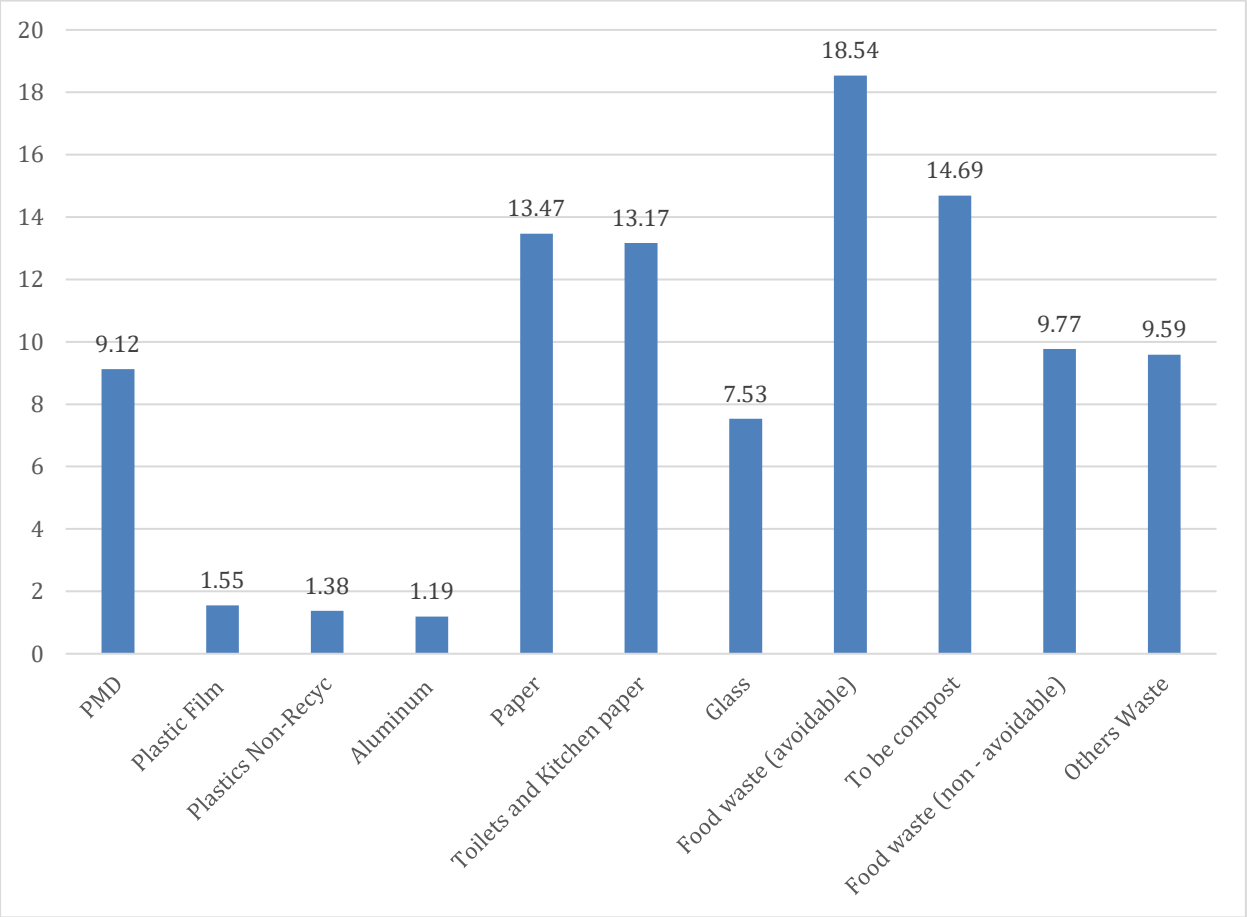


Diagram 2: Solid waste compositional analysis (results are acceptable at $p < 0.05$)

The results of the Global Composition of MSW as presented by the World Bank Group in 2018 is presented in Diagram 3. Results revealed that food, green waste, paper and plastic are of paramount importance. The results from the parish of Larnaka Municipality study, presented in Diagram 2, do not differ to a large extent in relation to the results of the World Bank Group analysis of solid waste.

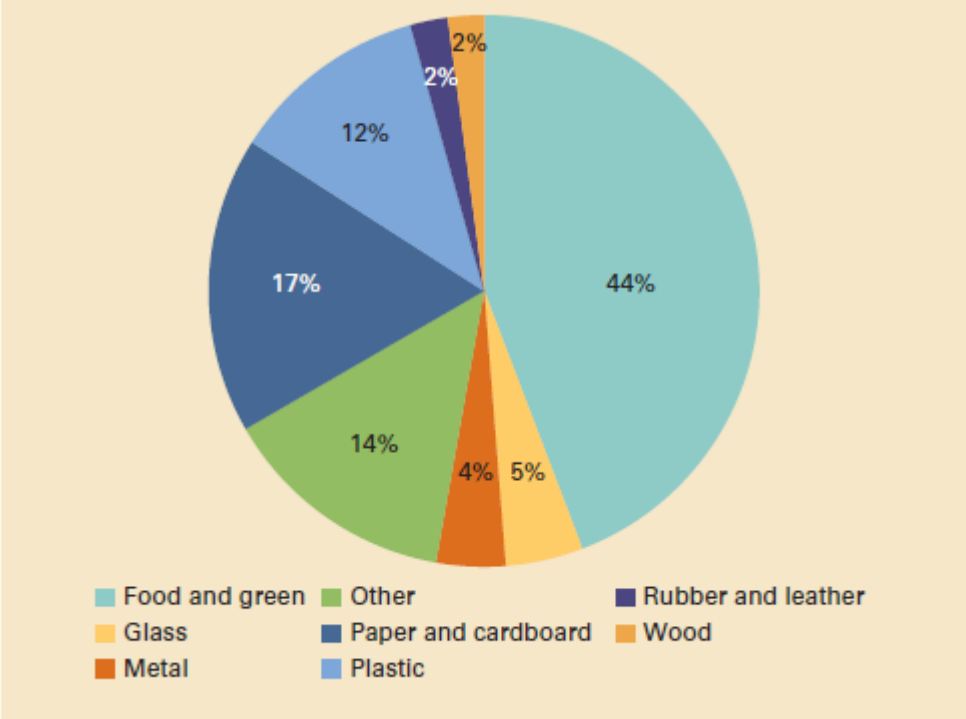


Diagram 3: Global composition of MSW (World Bank Group, 2018)

As far as the subcategories in the PMD category is concerned the percentage of each subtype is as follows: the metallic packaging (23.41%), plastic water bottles (17.85%), PET type packages (17.06%) and carton boxes of milk/juice (15.07%).

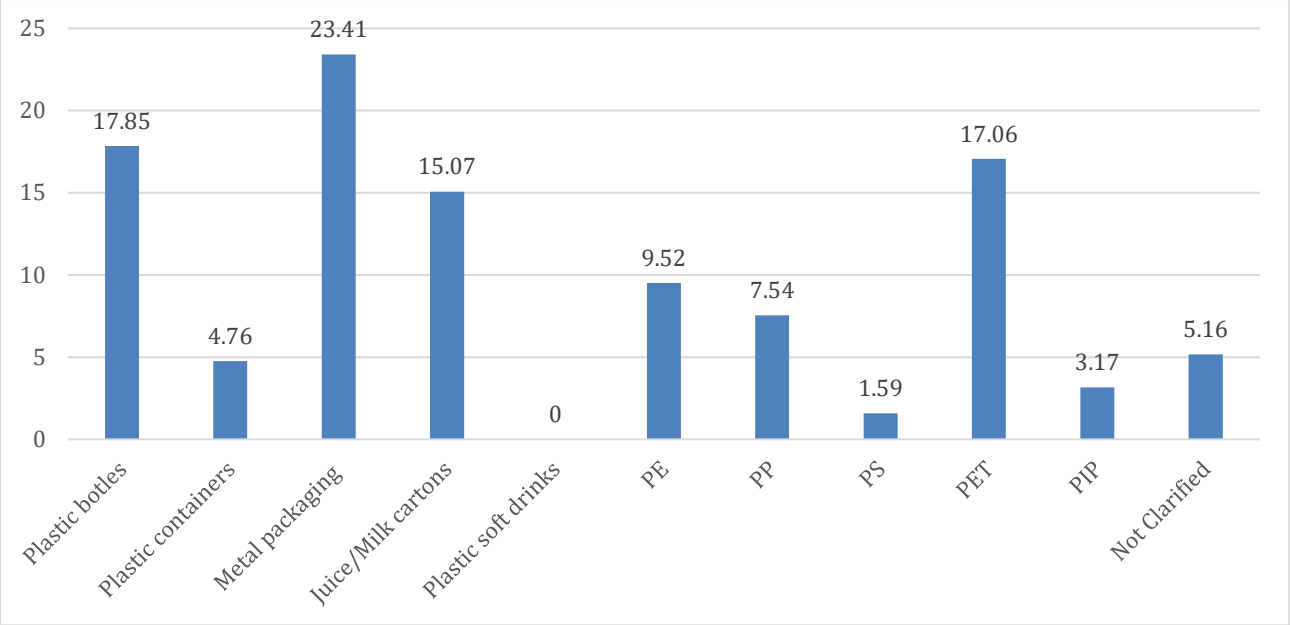


Diagram 4: PMD waste compositional analysis (results are acceptable at $p < 0.05$)

Within the paper category, office paper was found in a larger percentage of 34.55%. This was followed by paper packaging (bag, wrapping, cardboard) 27.07%, and flyers (22.31%). An important fact too, is that no newspapers have been identified, which is related to younger generational habits and the influence of electronic information.

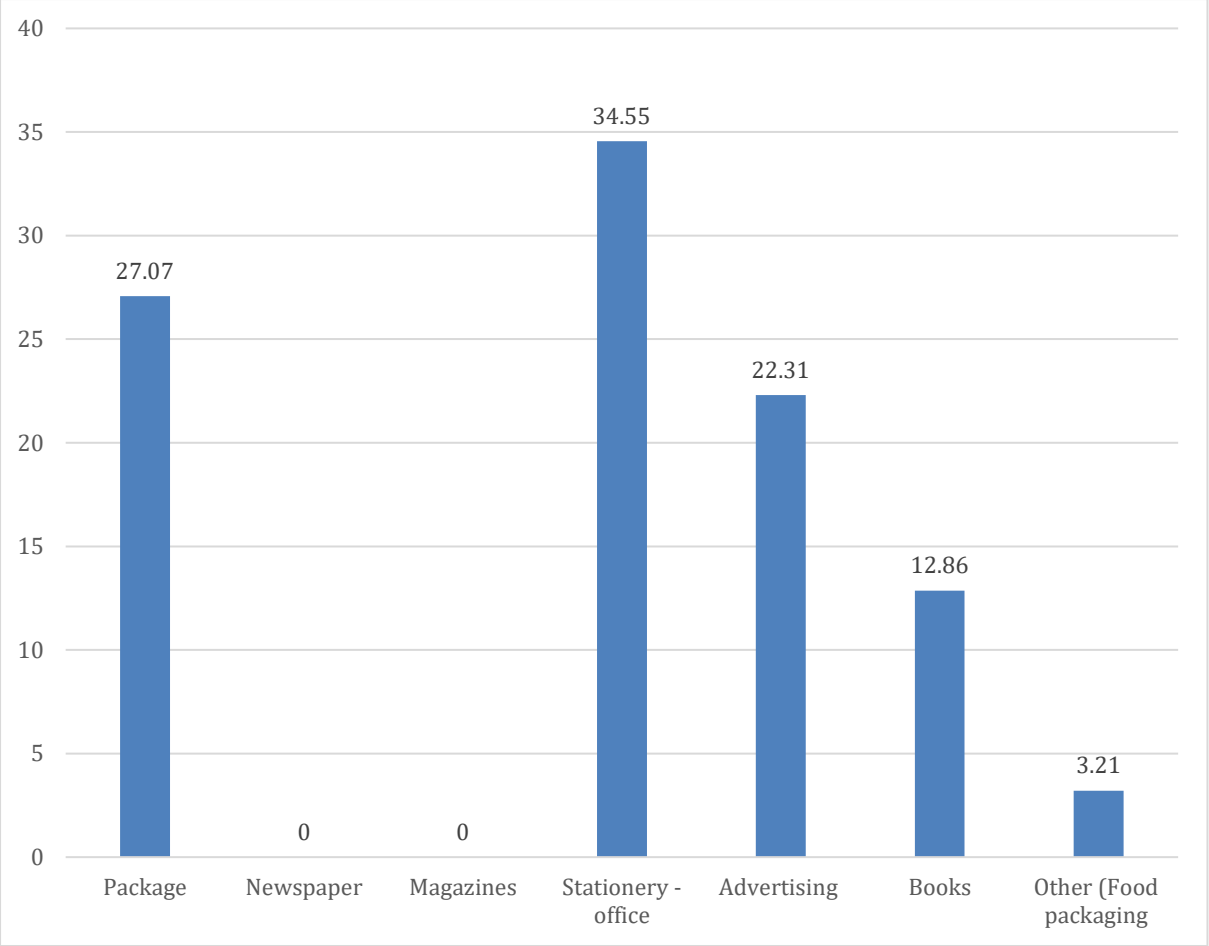


Diagram 5: Paper compositional analysis (results are acceptable at $p < 0.05$)

In the compositional analysis of the glass category mainly consists of white glass bottles 50.96%, 39.9% bottles with color and 9.14% consisted of crushed glass.

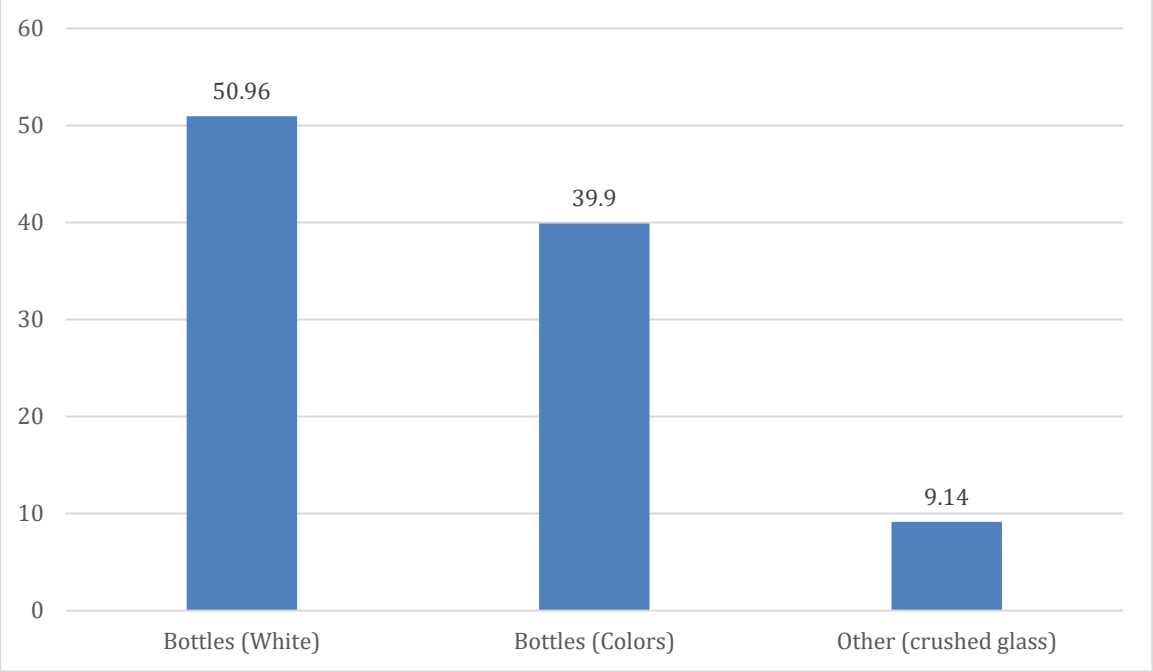


Diagram 6: Glass compositional analysis (results are acceptable at $p < 0.05$)

In regards to waste which does not belong to any of the above categories, it was classified in the category “Other waste”, in which textiles were found at a greater percentage of 40.51%, at a rate of 16.46% for rubble (mainly stones and soil), 12.72% were shoes, 7.27 wood materials, 5.19% at a rate of toys, 3.52% WEEE and 3.32% polystyrene from food packaging.

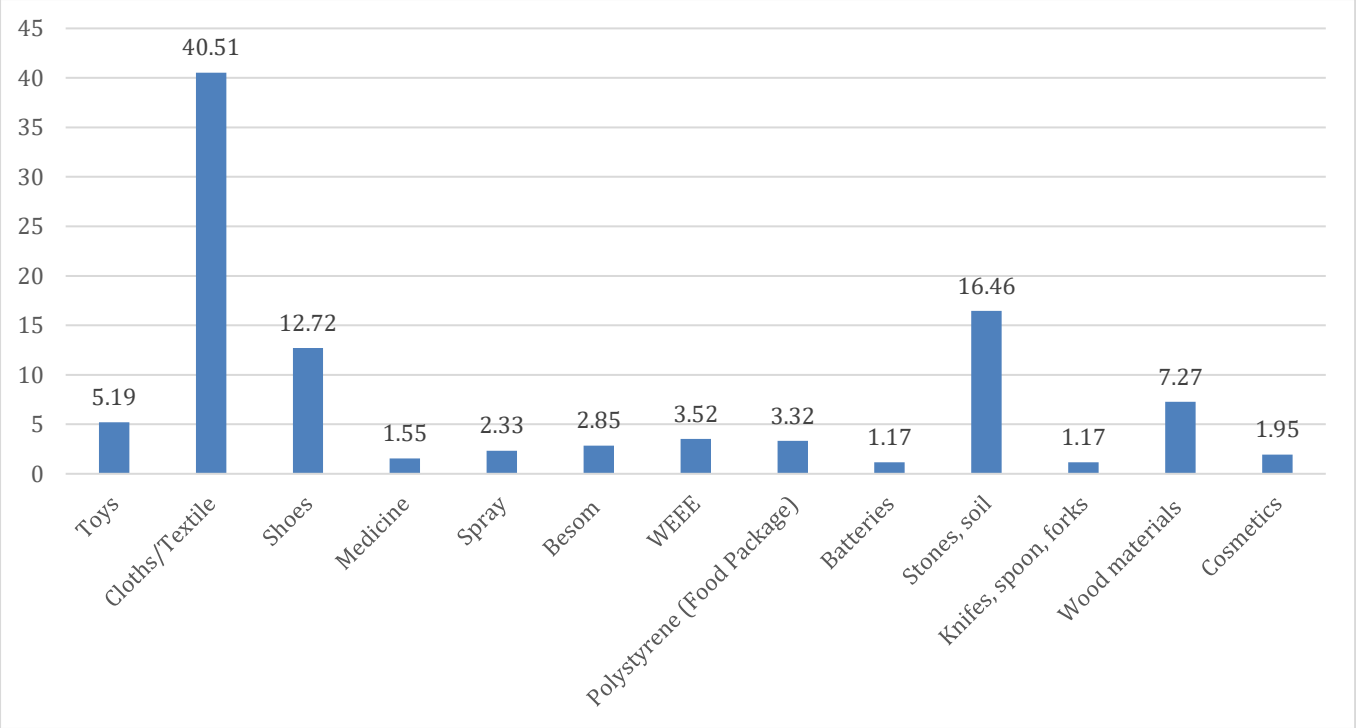


Diagram 7: "Other waste" stream compositional analysis (results are acceptable at $p < 0.05$)

In the category of waste that could be used as compost, a higher percentage of 79.82% of the pruning that could have been used for composting at the green point, was not. Furthermore, the citizens could also produce compost in their own space and use the compost in their own garden. Vegetables were identified at a rate of 18.71% and coffee at a rate of 1.47%.

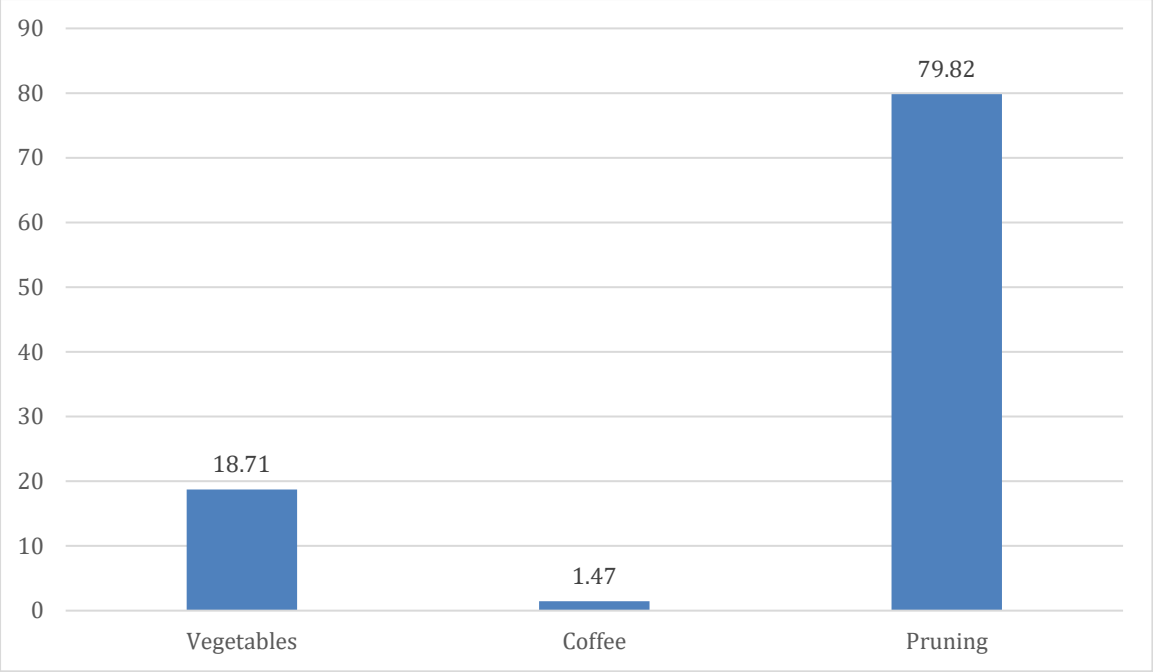


Diagram 8: " To be composted" waste composition analysis (results are acceptable at $p < 0.05$)

In the category of avoidable food waste, a high percentage of bread and pasta waste derivatives were identified in the quality composition (24.28%). Analysis also uncovered substantial amounts of meat (20.3%), milk products (10.59%), bakery products (9.27%), fish products (8.16%), lemons (4.63%), cucumbers (4.19%), candies (4.19%) and bakery products (3.53%).

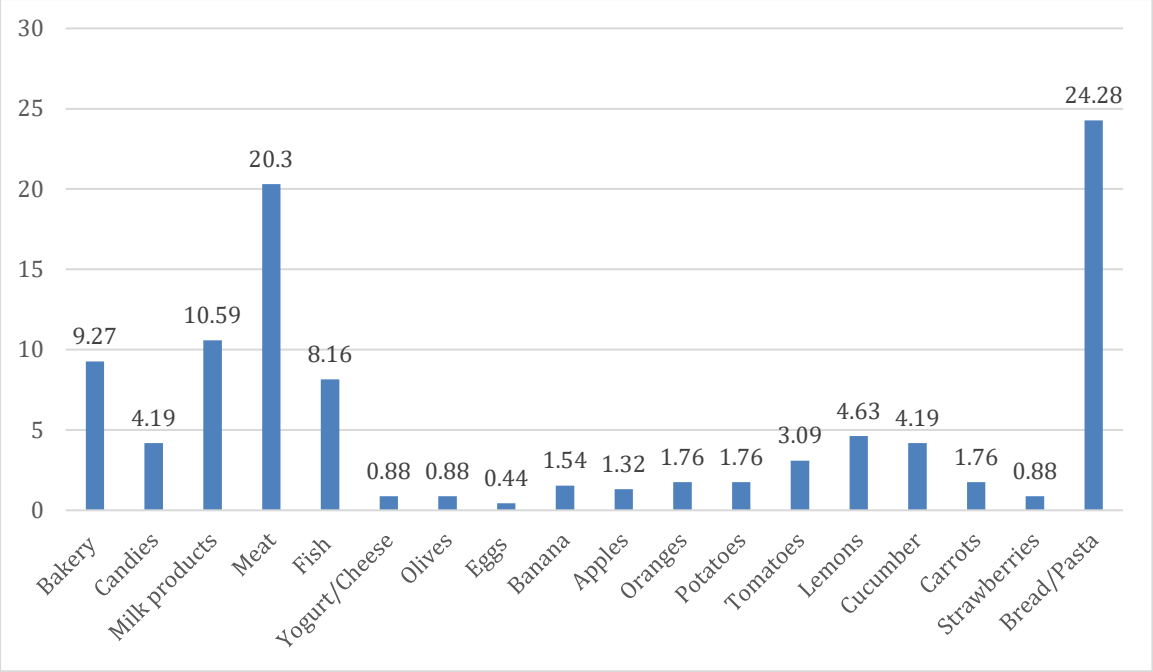


Diagram 9: Food waste (avoidable) stream (the results are acceptable at the level of confidence $p < 0.05$)

The most common types of food waste were mainly residues from consumer dishes and foodstuffs which were not consumed, therefore ending up as waste.

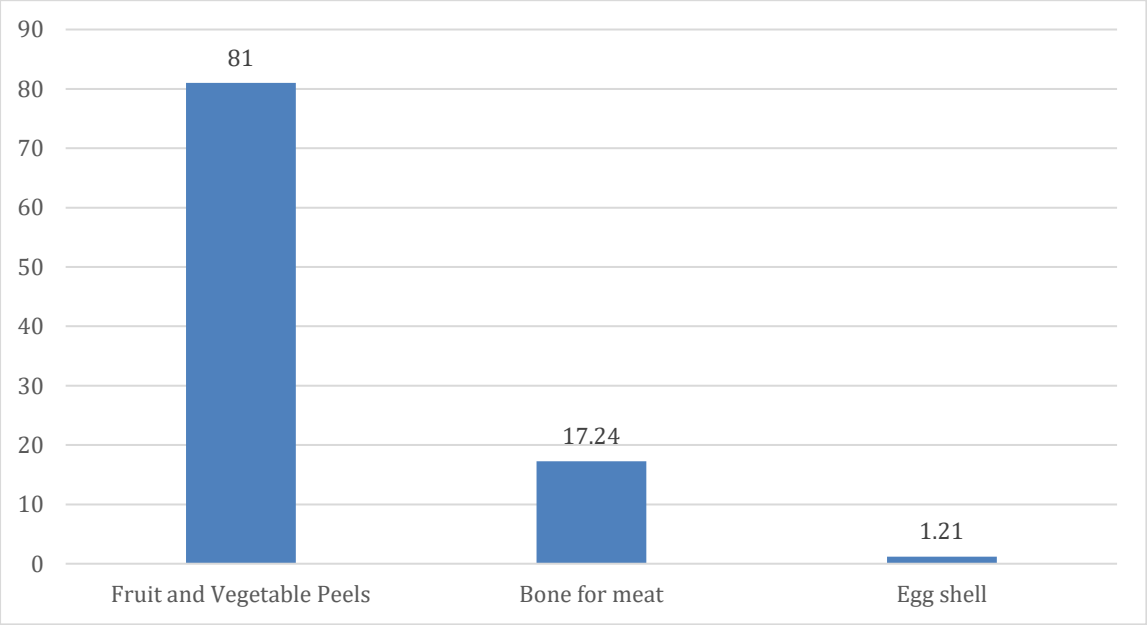


Diagram 10: Food waste (non-avoidable) stream (the results are acceptable at the level if confidence $p < 0.05$)

The analysis of the composition of the solid waste produced from the study area is describe in Diagram 11.

The main quantities of waste concerned avoidable food waste (27.04%) and 15.6% products that could be used for composting (green waste, peel). Other quantities included 12.3 %non-avoidable food waste, 8.15% ''other waste", 7.01% paper, 4.14% PMD, 2.68% glass, 2.67% plastic films, 1.01% plastics non-recyclable and 0.5% aluminum.

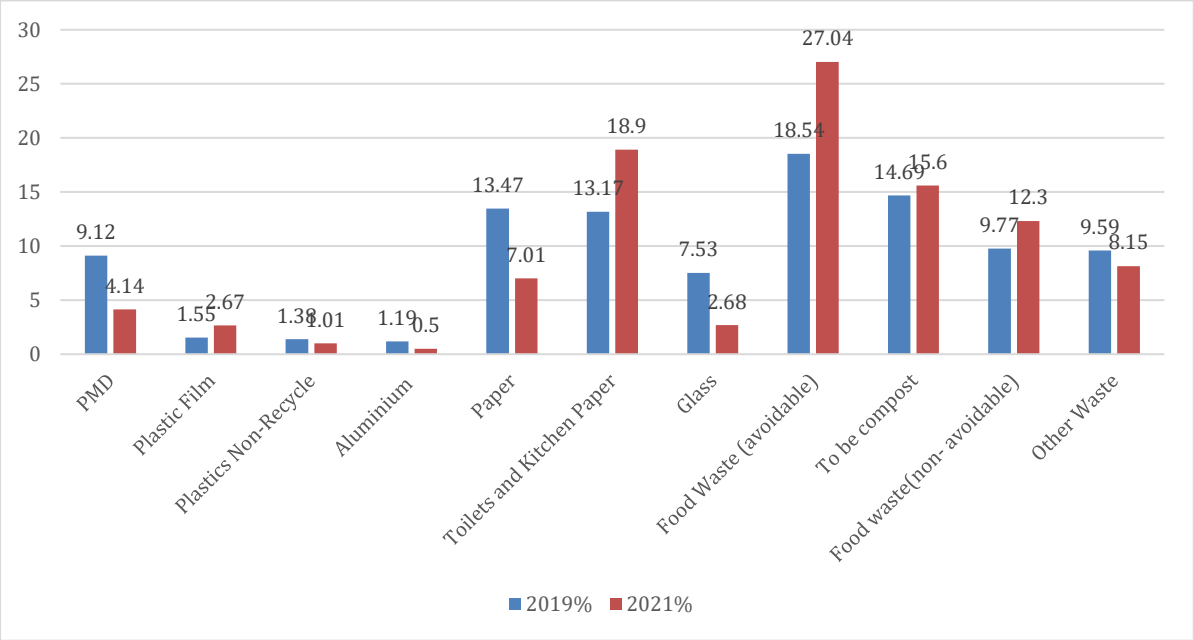


Diagram 11: Solid waste compositional analysis 2(results are acceptable at $p < 0.05$)

As far as the subcategories in the PMD category is concerned the percentage of each subtype is as follows: the metallic packaging (22.5%), carton boxes of milk/juice (22.05%), PET type packages (15.8%) and plastic water bottles (10.12%).

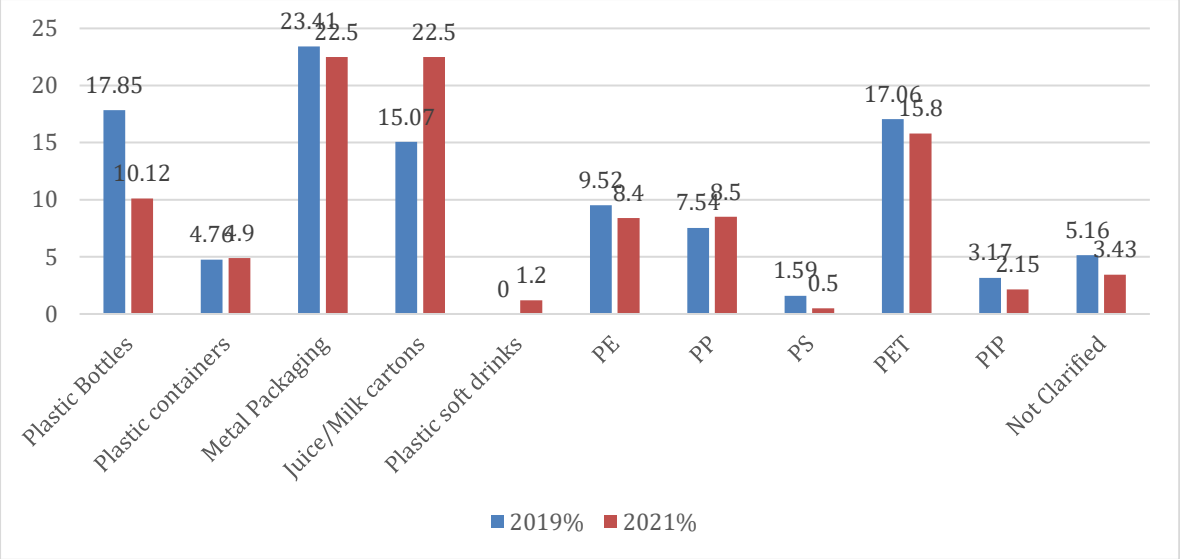


Diagram 12: PMD waste compositional analysis (results are acceptable at $p < 0.05$)

Within the paper category, paper packaging (bag, wrapping, cardboard) was found in a larger percentage of 35.9%. This was followed by office paper 27.59%, and flyers (26.25%). No newspapers and magazines have been identified.

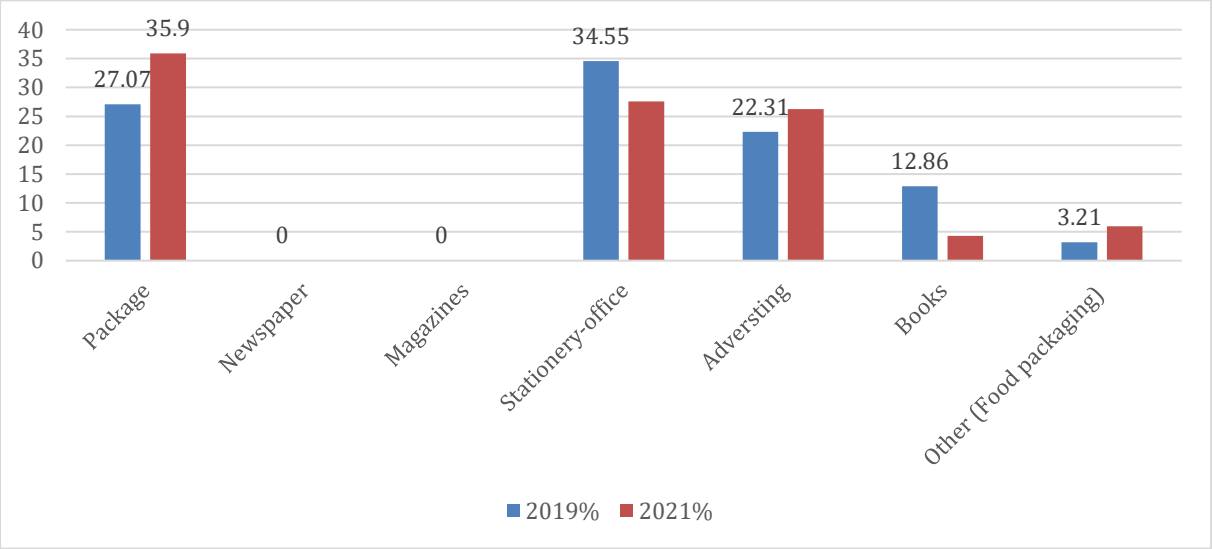


Diagram 13: Paper compositional analysis (results are acceptable at $p < 0.05$)

In the compositional analysis of the glass category mainly consists of colors glass bottles 40%, white glass bottles 35% and 25% consisted of crushed glass.

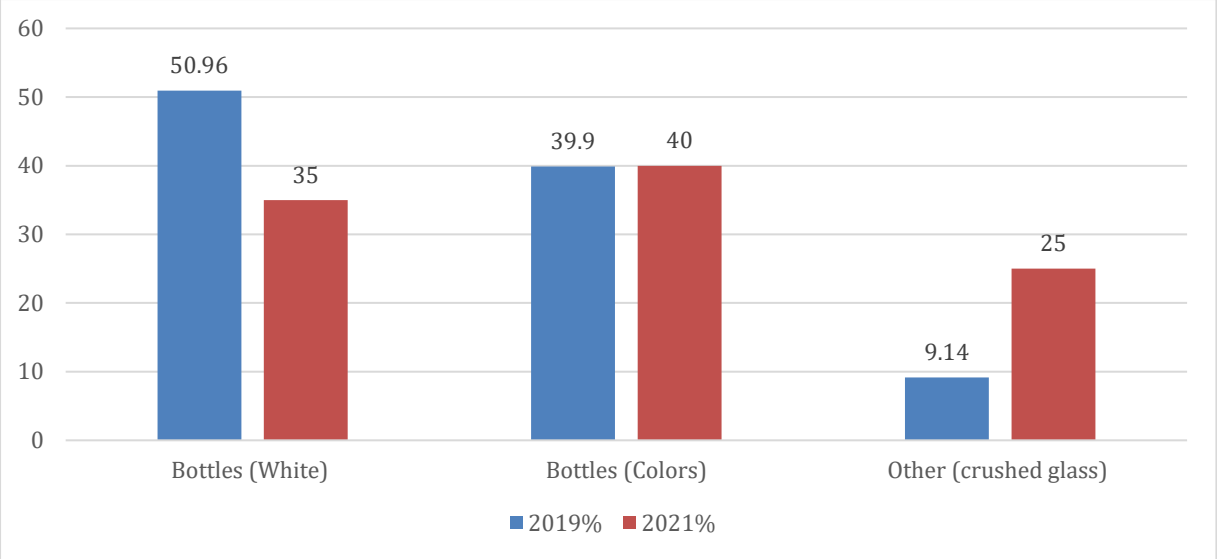


Diagram 14: Glass compositional analysis (results are acceptable at $p < 0.05$)

In regards to waste which does not belong to any of the above categories, it was classified in the category "Other waste", in which textiles were found at a greater percentage of 34%, at a rate of 22.6% for rubble (mainly stones and soil),12.5 wood materials, 6.9% polystyrene from food packaging, 5.9% were shoes, 4.9% WEEE and 3.25% at a rate of toys.

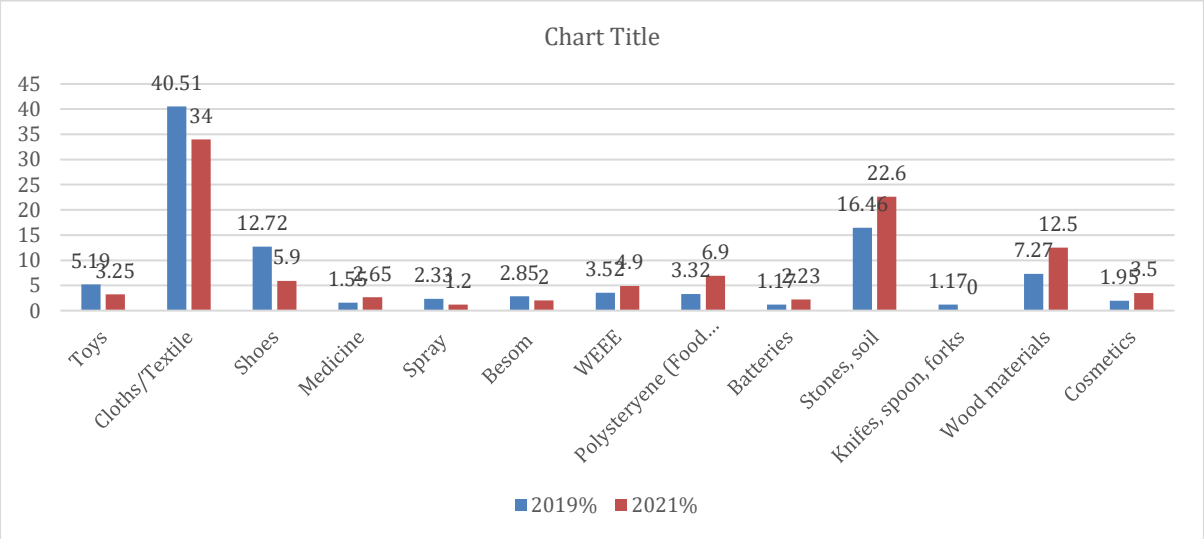


Diagram 15: "Other waste" stream compositional analysis (results are acceptable at $p < 0.05$)

In the category of waste that could be used as compost, a higher percentage of 70.3% of the pruning that could have been used for composting at the green point, was not.

Furthermore, the citizens could also produce compost in their own space and use the compost in their own garden. Vegetables were identified at a rate of 22.9% and coffee at a rate of 6.8%.

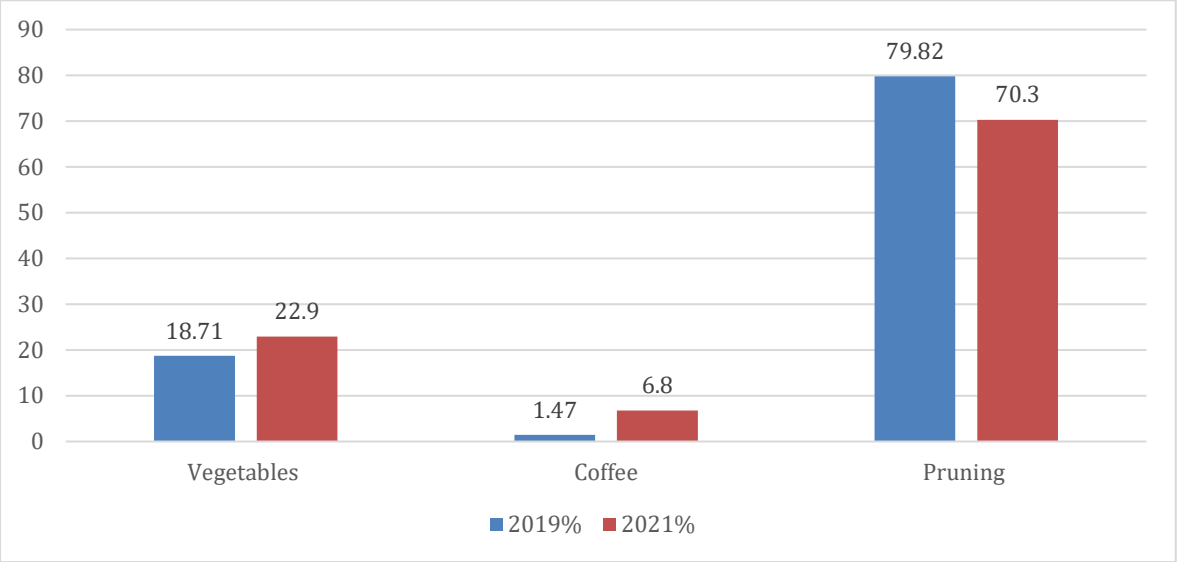


Diagram 16: " To be composted" waste composition analysis (results are acceptable at $p < 0.05$)

In the category of avoidable food waste, a high percentage of meat waste was identified in the quality composition at 25.9%. Analysis also uncovered substantial amounts of bread and pasta waste at 21.8%. Fish products at 9.15%, milk products (8.9%), bakery products (6.7%), lemons (6.6%), cucumbers (4.8%), tomatoes (4,05%) and candies (3.5%).

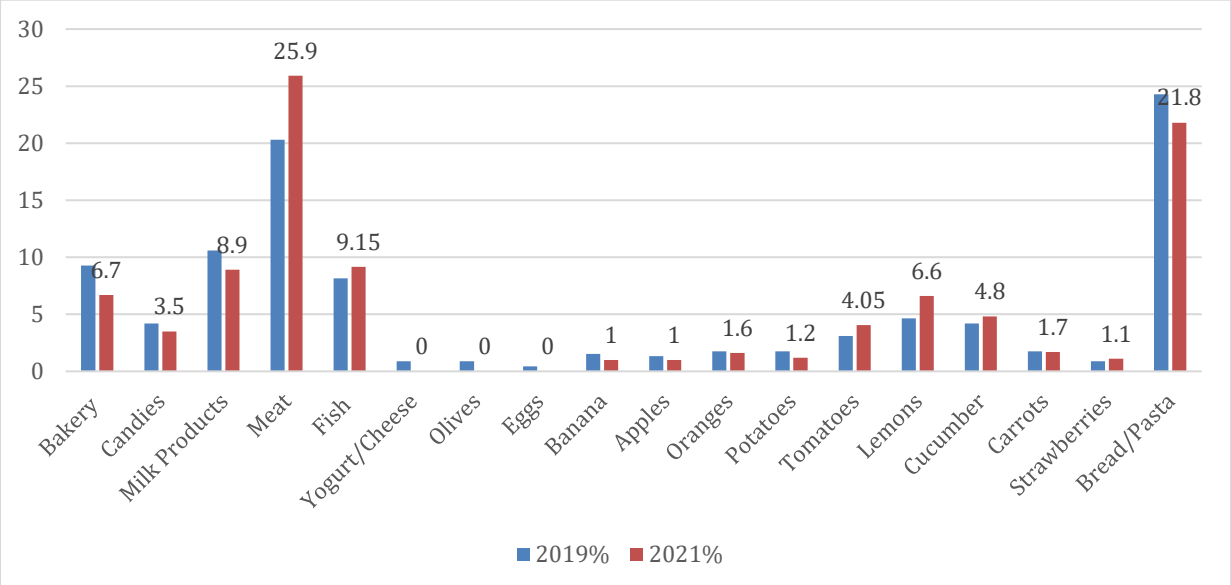


Diagram 17: Food waste (avoidable) stream (the results are acceptable at the level of confidence $p < 0.05$)

The most common types of food wastage were mainly residues from consumer dishes and foodstuffs which were not consumed, therefore ending up as waste.

In food waste with non-avoidable ingredients the highly amount were covered from fruit and vegetables peels (72%), bones from meat (24,6%) and egg shells 3.4%.

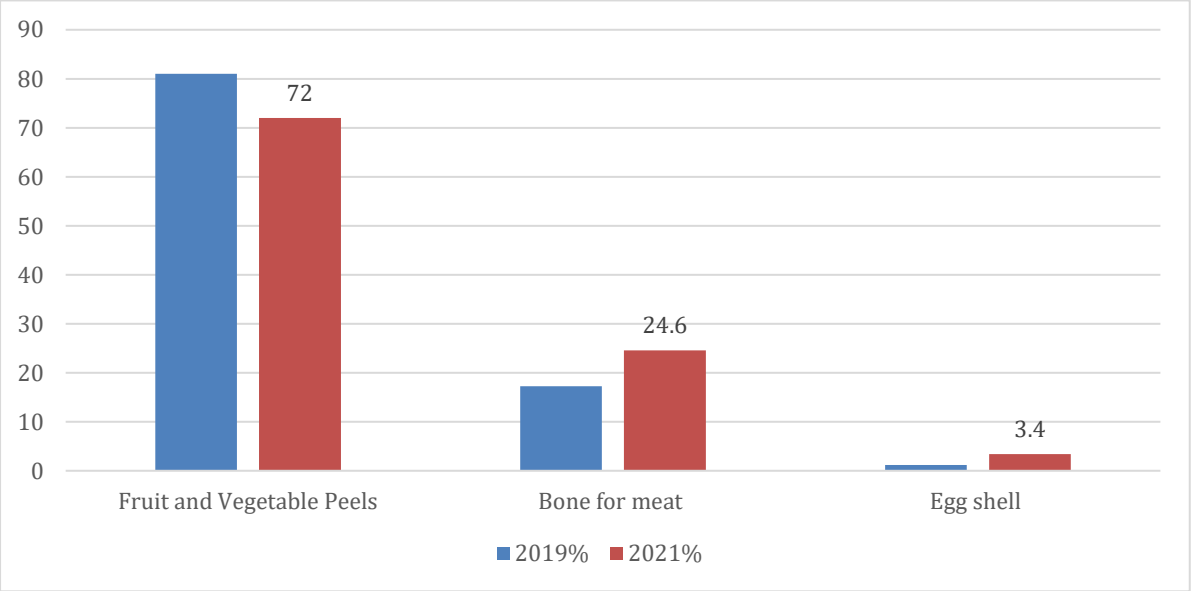


Diagram 18: Food waste (non-avoidable) stream (the results are acceptable at the level if confidence $p < 0.05$)

5. Discussion

Of great concern is the fact that during the waste formation analysis, large quantities of food products have been identified as waste without being used by the consumer before their expiry date. This was particularly the case with high-quality food items (fruits, vegetables), which could potentially be reused in the manufacture of other types of food products (such as fruit cakes, jam or vegetable soup).

Citizens require information in regard to minimizing and managing their waste and improving their behavior through personal interviews, information provided via local radio stations, articles in local newspapers, and brochures delivered door to door. Williams and Taylor (2014) stated that the public should be trained to consider waste as resources and not as goods that we simply consume and then disposed of. Ambitious educational objectives must be adopted through environmental teachings at schools in an attractive, easy and understandable manner.

Furthermore, an important concern is the fact that large proportions of materials such as paper, glass and PMD could end up in recycling bins which the Municipality has at their disposal. The Municipality of Larnaka has placed throughout the city 400 blue bins for PMD, brown bins for paper in 25 locations and 65 glass storage bins for use by the citizens. Also, in the Makenzy area a machine has been installed, where financial incentive is provided (0.01€/package) to those citizens who recycle plastic, glass and metal packaging. In addition, 13 paper compressors and 4 PMD compressors have been placed. Finally, by the end of 2019, the installation of underground bins will be completed for the collection of recyclable and food waste.

According to Ventour (2008) and Zorpas et al. (2018) 81% of food waste making up its composition, consists of foods that could have been consumed (avoidable waste) if they were manufactured and managed in a different way. The FAO (2015) considered that the lost food waste constitutes 30% of all food items, 1.3 billion tonnes per year, which is the direct result of the consumer's behavior (Gustavsson et al., 2011; Chalak et al., 2016; World Bank Group, 2018; Zorpas et al., 2018). By definition, food waste in the developing countries is directly linked to the consumer's behavior as well as societal attitudes, lifestyle, daily habits, incomes, education, awareness, infrastructure and the policies of an area (FAO, 2011; Zorpas et al., 2015; Abeliotis et al., 2015).

WHO (World Health Organization) appreciates greenhouse gas emissions from foods that end up in landfills without being consumed at 3.3 Gt CO_2. Waste water from food that has not been consumed is approx 250 km^3 (equivalent to three times the volume of Geneva lake) (FAO, 2013). In the EU, almost every year, 15t of materials per person are used and

every EU citizen on average generates 4.5t of waste each year, where more than half of the waste ends up in landfills.

This illustrates the urgent need to develop a sustainable solution that will help shape the waste management for future generations.

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