UNIVERSITY OF PADUA

ICEA DEPARTMENT

MASTER THESIS IN ENVIRONMENTAL ENGINEERING

INTRODUCTION OF SOURCE SEGREGATION OF WASTE IN THE MUNICIPALITY OF CARINI (PA)

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"*A clever person solves a problem. A wise person avoids it.*"

-- *(Albert Einstein)*

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Introduction

An efficient management of municipal waste in the territory requires knowledge of the quantities produced and of their merceological composition. In order to obtain this information, the waste is subjected to merceological analysis; these analysis represent an indispensable tool to learn about the physical composition of the waste collected, managed, recovered or disposed of and optimize the management and operational strategies.

The waste emergency in the Palermo province is due to a mismanagement that is limited to a sporadic collection without taking into account the possibility of the separate collection. This happens also in Carini, a municipality 25 km far from Palermo. The work aims to investigate which would be the immediate answer of the citizen of a new waste management in Carini with the introduction of a separate collection, which needs their participation by a source segregation.

The study is articulated in four levels; after having given an introduction of the actual legislation and the urban waste contest in Europe, Italy and Sicily in the first two chapters, the practical work starts. Firstly a description of the data about the quantity of residual waste collected from two samples of families is made, subsequently two merceological analysis are styled in order to describe the quality of the segregated residual fraction and to make a quantitative-economic projection to all the municipality and to conclude considerations on the recyclable and reusable fractions are made.

The principal goal of the work is to demonstrate that, if a separate collection would be managed in the municipality of Carini, the citizen would react with a good efficiency of source segregation; moreover the amount of waste disposed in to the landfill would considerably decrease, and so also the transport cost.

Chapter 1

Legislation

Every year 2 billion tonnes of waste more or less, including particularly hazardous waste, are produced in the Member States, and this figure is steadily rising. In order to breaking the link between growth and waste generation, the European Union has provided itself with a legal framework aimed at the whole waste cycle from generation to disposal, placing the emphasis on recovery and recycling.

1.1 The European Directive

The document that the Member States has to refer to about waste is the Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste.

The Directive establishes a legal framework for the treatment of waste in the EU. It sets the basic concepts and definitions related to waste management and lays down waste management principles for all other EU legislation related to waste, such as the "polluter pays principle", the "extended producer responsibility" and the "waste hierarchy". It incorporates provisions on hazardous waste and waste oils (old Directives on hazardous waste and waste oils being repealed with the effect from 12 December 2010), and includes two new recycling and recovery targets to be achieved by 2020: 50% preparing for re-use and recycling of certain waste materials from households and other origins similar to households, and 70% preparing for re-use, recycling and other recovery of construction and demolition waste. The Directive requires that Member States adopt waste management plans and waste prevention programmes.

This Directive sets key concepts as:

- *By-Products* (Art. 5): a substance or object, resulting from a production process, the primary aim of which is not the production of that item, may be regarded as not being waste but as being a by-product only if the following conditions are

met: further use of the substance or object is certain; the substance or object can be used directly without any further processing other than normal industrial practice; the substance or object is produced as an integral part of a production process; further use is lawful, i.e. the substance or object fulfils all relevant product, environmental and health protection requirements for the specific use and will not lead to overall adverse environmental or human health impacts;

- *End-of-Waste* (Art. 6): certain specified waste shall cease to be waste within the meaning of point (1) of Article 3 when it has undergone a recovery, including recycling, operation and complies with specific criteria to be developed in accordance with the following conditions: the substance or object is commonly used for specific purposes; a market or demand exists for such a substance or object; the substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products; the use of the substance or object will not lead to overall adverse environmental or human health impacts. The criteria shall include limit values for pollutants where necessary and shall take into account any possible adverse environmental effects of the substance or object.
- *Recycling rate* (Art. 11.2): in order to comply with the objectives of this Directive, and move towards a European recycling society with a high level of resource efficiency, Member States shall take the necessary measures designed to achieve the following targets: (a) by 2020, the preparing for re-use and the recycling of waste materials such as at least paper, metal, plastic and glass from households and possibly from other origins as far as these waste streams are similar to waste from households, shall be increased to a minimum of overall 50 % by weight; (b) by 2020, the preparing for re-use, recycling and other material recovery, including backfilling operations using waste to substitute other materials, of non-hazardous construction and demolition waste shall be increased to a minimum of 70 % by weight.
- Biowaste (Art. 22): Member States shall take measures, as appropriate, and in accordance with Articles 4 and 13, to encourage: the separate collection of bio-waste with a view to the composting and digestion of bio-waste; the treatment of bio-waste in a way that fulfils a high level of environmental protection; the use of environmentally safe materials produced from bio-waste.

1.1.1 Waste hierarchy

In order to better protect the environment, the Member States should take measures for the treatment of their waste in line with the following hierarchy which is showed in Figure 1.1.

Figure 1.1. *Waste management hierarchy according to the European Directive 2008/98/CE*

Member States can implement legislative measures with a view to reinforcing this waste treatment hierarchy. However, they should ensure that waste management does not endanger human health and it is not harmful to the environment.

The generation of waste is increasing within the European Union. It has become of prime importance to specify basic notions so as to better organize waste management activities.

- Waste: any substance or object which the holder discards or intends or is required to discard.
- Waste management: the collection, transport, recovery and disposal of waste, including the supervision of such operations and the after-care of disposal sites, and including actions taken as a dealer or broker.
- Prevention: measures taken before a substance, material or product has become waste.
- Recovery: any operation the principal result of which is waste serving a useful purpose.
- Recycling: any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes.

It is also essential to reinforce measures to be taken with regard to prevention as well as the reduction of the impacts of waste generation and waste management on the environment. Finally, the recovery of waste should be encouraged so as to preserve natural resources.

1.1.2 Landfill of waste

The European Union, with the Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste, has laid down strict requirements for landfills to prevent and reduce as far as possible the negative effects on the environment, specifically on surface water, groundwater, soil, air and human health.
The Directive is intended to prevent or reduce the adverse effects of the landfill of waste on the environment. It defines the different categories of waste (municipal waste, hazardous waste, non-hazardous waste and inert waste) and applies to all landfills.
Landfills are divided into three classes: landfills for hazardous waste; landfills for non-hazardous waste and landfills for inert waste. The Directive obliges Member States to minimize biodegradable waste to landfills to 75% by 2006, 50% by 2009 and 35% by 2016, and to treat it before disposal.

1.2 The Italian Directive

The Italian waste integrated management is collected in the Legislative Decree of 3 April 2006 n. 152 ("Norme in materia ambientale ") also known as Testo unico ambientale, which sets rules for the waste management and the remediation of contaminated sites. It follows the European Directive 2008/96 and establishes the following strategies:

- *priorities* (art 179): respect of the hierarchy described in § 1.1.1, development of clean technologies, design and marketing of products that do not contribute or take a minimum contribution to the production of waste and pollution, technological improvements to eliminate the presence of hazardous substances in waste, active role of government in the recycling of waste and their use as an energy source;

- *prevention* (art 180): proper assessment of the environmental impact of every product throughout its entire life cycle, specifications that consider the ability to prevent the production, promote agreements and experimental programs to prevent and reduce the amount and hazard of waste, implement of the DL 18 February 2005 n. 59 and Directive 96/61/EC specifically for integrated pollution prevention and reduction;
- *recycle and recovery* (art 181): reuse and recycling, production of secondary raw material by treating the waste, encourage through economic measures and specifications the market for reused products, using waste to produce energy (energy recovery (cold biological oxidation, gasification, incineration).

Therefore, if the first level of attention is directed to the need to prevent the production of waste and reduce their hazard, the next step concerns the need to reuse the products and , if you cannot reuse, recycle materials. Finally, only with regard to the material that has not been possible to reuse and recycle, and then the underscreen, the options are energy recovery and landfilling.

1.3 The regional regulation

In Sicily the waste management is regulated by the Regional Law of 8 April 2010, n. 9 “Gestione integrata dei rifiuti e bonifica dei siti inquinati”, whose purposes are prevent the production of waste and reduce their aggressiveness, to promote the reuse, recycling and recovery to help reduce landfill, promote recycling, increase the implementation of plant technology with low environmental impact, reduce waste handling with the optimization of disposal plants next to the place of production, recognizing the role of municipalities as responsible for the service provided to its citizens, to pursue the economic equilibrium of public service with the resources available and the revenue derivable from the collection.

Article 5 of Regional Law provides that in Sicily, in the new system, the performance of the integrated waste management, public service and supra-local scope having economic importance, must be organized in optimum areas, territorial subdivisions dimensions coincide with those of the provinces, except for the tenth catchment area on the smaller islands. Within each optimum area, the service of integrated waste

management is organized, disciplined and committed, on the basis of an area plan, a stock company for the regulation of waste management service, SRR, made compulsorily , by municipalities and provinces included in the regional territory.
The regional law of April 8, 2010 n. 9 attaches primarily to S.R.R. tasks of a general nature, regulation and control of the service, within the territorial jurisdiction, in order to ensure the efficiency, effectiveness and economic and financial balance of the management.
According with the "Direttiva in materia di gestione integrata dei rifiuti" of 27 September 2013, as required by the Article 19 of the regional law n. 9/2010, every activity of integrated waste cycle management has ceased by the companies and consortia. Indeed the regulatory bodies didn't complete the needed procedure for the definitive assignment of the management service despite the numerous extensions activated by the Regional department. In order to avoid the public service interruption, and the consequent health and sanitary problems, the President of the Region issued the decree n. 8 /RIF of 27 September 2013.
The decree anticipates a special form of waste management to realize by the intervention of special commissioners who have the task to guarantee, in name of municipalities, the continuity of the service.

1.3.1 Management plan of municipal solid waste

Pursuant to article 199 of Legislative Decree N.152/2006 and art. 9 of Act 9/2010, the regional waste plan is a tool for regional planning that defines the criteria and procedures to promote the programming and operation of the integrated waste management, encouraging the reduction, the forms of aggregated collection of post-consumer materials, directing the collection of aggregate or individual materials for recycling and recovery evenly in the region, in order to generate an industrial chain of recycling and recovery that can count on a certain flow of matter in quality and quantity.
The relevant points of the program are:

- Actions of prevention and reduction of the production of the urban waste promoting home composting, awareness campaigns, regulations for the sustainable management of fairs and festivals, the use of reusable nappies;
- Operational guidelines on separate collection systems;

- Options for the pre-treatment of urban waste residue from the separate collection implementing a net of treatment systems connected with the final destination which has the following strategic goals: reduction of weight and volume of waste to send to the landfill, intervene drastically on the fermentability of waste to be landfilled, having a good capacity of providing treatment system each regional area without diseconomies, allow and accompany the progressive separate collection growth;
- Energy development of waste with thermal processes as incineration, gasification, pyrolysis, technologies based on combined processes, use of RDF in cement;
- Anaerobic digestion;
- Identification of areas not suitable for plants location of mechanical-biological treatment, composting, anaerobic digestion energy development and landfills taking in account the constraints exclusionary, the constraints to be considered;
- Normalized determination of the rate sustainability;
- Program for the adaptation of landfills taking into account the necessary specifications to determine the volumes of waste which need to be landfilled;
- Timetable for action for the province of Palermo;
- Economical plan that contains a rough estimation of the costs of mechanical plants, stabilization plants and landfill required for each province.

Chapter 2

Waste management

Each year in the European Union alone it is thrown away 3 billion tonnes of waste. This amounts to about 6 tonnes of solid waste for every person, according to Eurostat statistics. The quantity and quality of waste produced is different per each European country, and it varies also within each country depending on geographical area and region.

2.1 European contest

Between 1990 and 1995, the amount of waste generated in Europe increased by 10%, according to the Organisation for Economic Cooperation and Development (OECD); most of what it is thrown away is either burnt in incinerators, or dumped into landfill sites (67%). By 2020, the OECD estimates, in Europe it could be generated 45% more waste than it was in 1995.

The EU's Sixth Environment Action Programme recognises waste prevention and management as one of four top priorities. The EU is in fact aiming for a significant cut in the amount of waste generated, through new waste prevention initiatives, better use of resources, and encouraging a shift to more sustainable consumption patterns.

The European Union's approach to waste management is based on the following principles:

- Waste prevention: is closely linked with improving manufacturing methods and influencing consumers to demand greener products and less packaging.
- Recycling and reuse: If waste cannot be prevented, as many of the materials as possible should be recovered, preferably by recycling. Several EU countries are already managing to recycle over 50% of packaging waste.

– Improving final disposal and monitoring: Where possible, waste that cannot be recycled or reused should be safely incinerated, with landfill only used as a last resort. Both these methods need close monitoring because of their potential for causing severe environmental damage.

Between 2011 and 2012 was a decline of urban waste production of 0,9% compared to 2010, from about 254.4 million tonnes to just under 252 million tonnes, following a reduction of 0.2% recorded between 2009 and 2010.

As far as the countries most populated, the greater reduction is recorded in Italy (-3.4%), followed by Germany, Spain and France with reductions of, respectively, 0,9%, 0,7% and 0,6% as showed in Figure 2.1 In contrast pose data for the UK, that show an increase of the waste products of 0.2%.

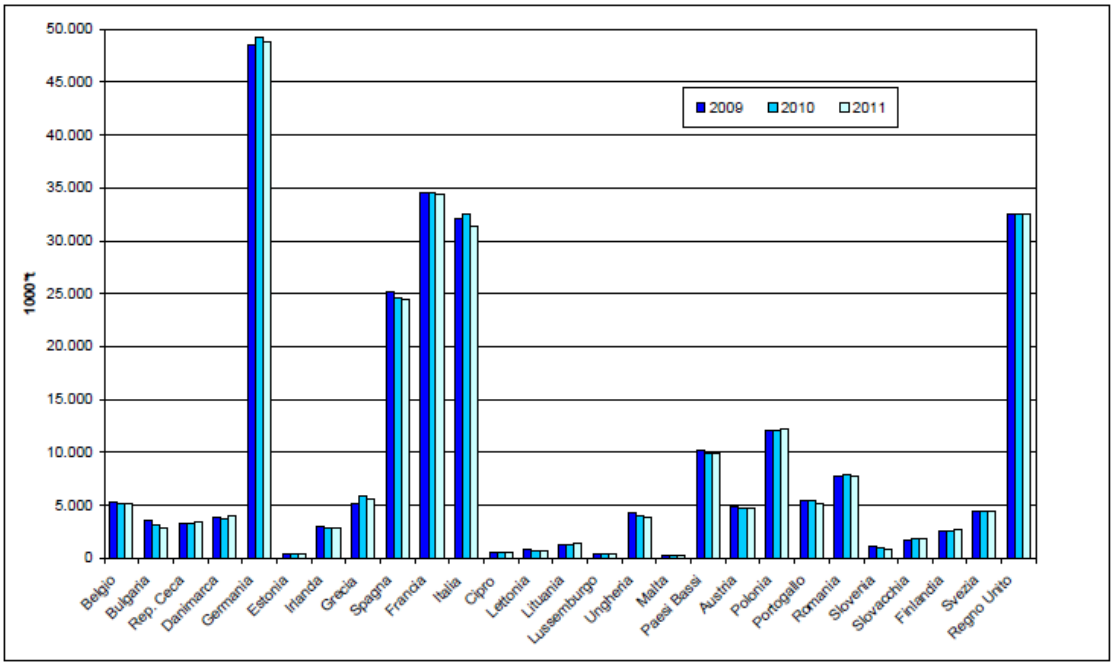


Figure 2.1. *Urban waste production in the EU (1000*t), years 2009-2011. Source: ISPRA elaborations on Eurostat data*

In 2011, the average production per capita is equal to 502 per inhabitant per year, marking a decrease of 1% compared to the previous year, confirming the downward trend recorded between 2009 and 2010 (-0.4%) . The variability of the data in the EU remains very high in 2011: it goes from 298 kg per inhabitant per year in Estonia to 718 kg per inhabitant per year in Denmark.

From the above, it is clear that in recent years is steadily gaining a trend towards a reduction of the total production and per capita municipal waste in the EU. On this figure undeniably affects the international economic crisis. But probably also because, beyond the crisis, they are affirming patterns of consumption and production more virtuous and attentive to the prevention and containment of waste production in line with the EU policies in the waste sector.

Is shown in Figure 2.2, for each Member State the percentage of the main forms of management, chosen by Eurostat, which are initiated municipal waste in 2011. About 36% of municipal waste managed in the 27 Member States is disposed of in landfills, about 23% is initiated for incineration, while about 26% and about 15% are initiated, respectively, to recycling and composting. It should be noted that, according to the Eurostat approach, in "composting", in addition to the aerobic treatment of the biodegradable fraction there is also the one of anaerobic.

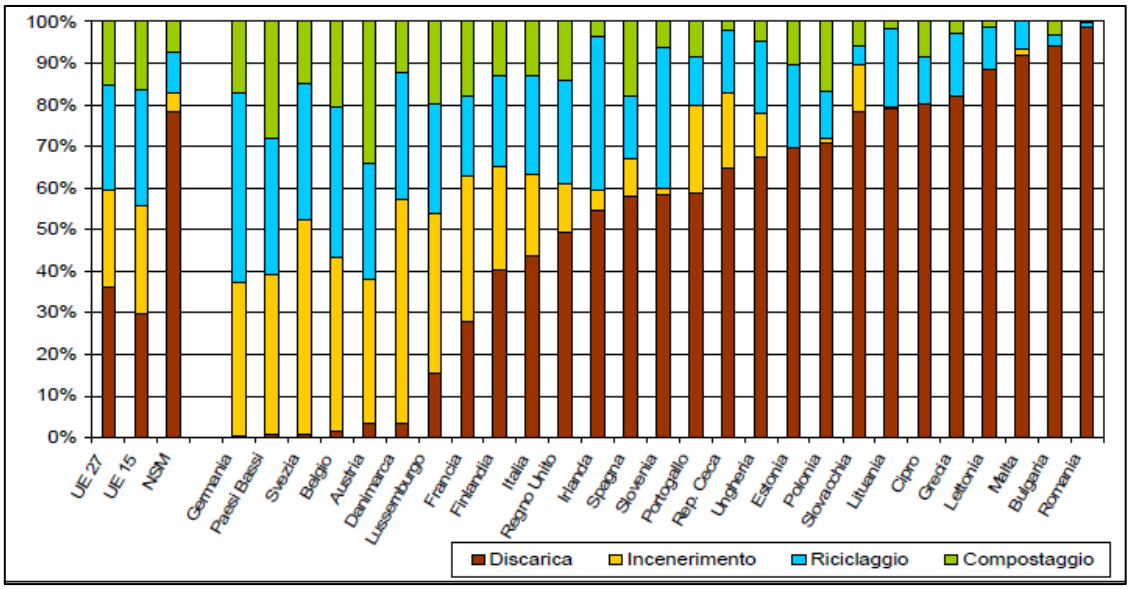


Figure 2.2. *Percentage distribution of urban waste management in the EU in 2011 (data sorted by increasing percentages of landfill). Source: ISPRA elaborations on Eurostat data*

The figure shows an extreme variability in the approach to solid waste management between the different Member States. With reference to the landfill disposal, it passes from percentages below 1% in Germany, the Netherlands and Sweden to percentage of 99% of Romania.

In the last three years, the consolidation of the implementation of policies and legislation aimed at reducing waste to landfill, in particular biodegradable waste, gave

considerable fruit. Between 2009 and 2011 there was a decrease of 8%, while between 2010 and 2011, the reduction is of 5,8%.

Otherwise the production of municipal waste, the amount of recyclable waste products has increased; in 2011 the recycling covers about 62,3 million tonnes of municipal waste. Compared to 2010, there was an increase in the quantities of 1,9%. If it is considered the per capita data (Figure 2.3), in 2011 started to recycle 124 kg/inhabitant per year of MSW, an increase of 1,6% compared to 2010.

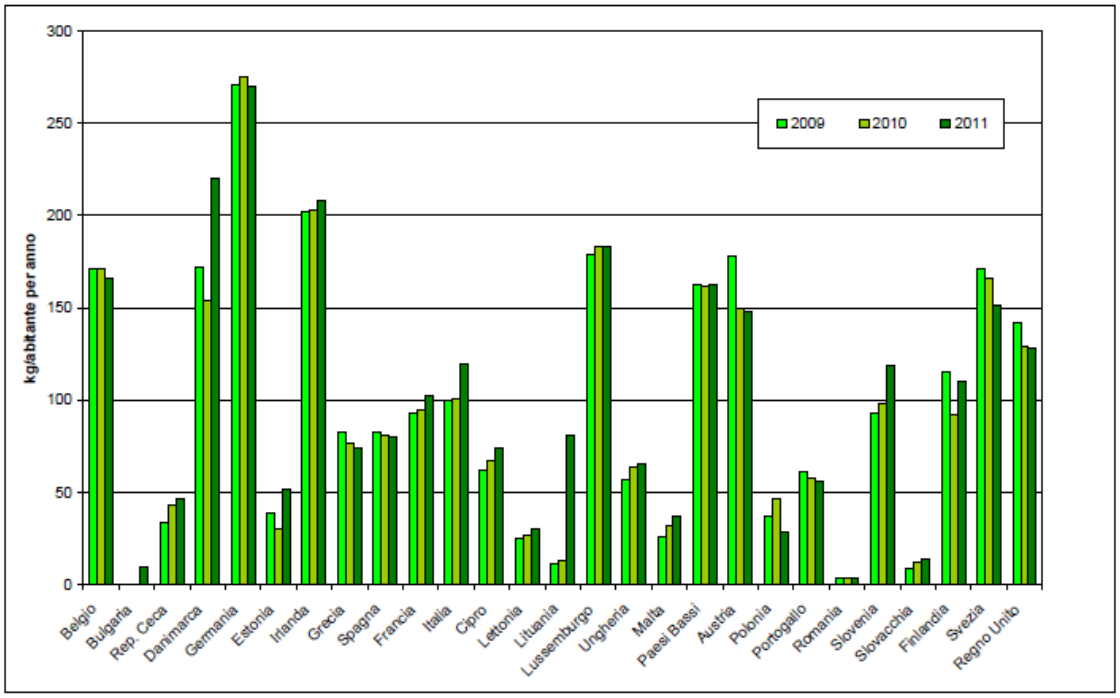


Figure 2.3. *Quantity per capita of municipal waste recycled in the EU (kg/ inhabitant per year), 2009–2011. Source: ISPRA elaborations on Eurostat data*

In 2011, the EU launched a composting approximately 36,9 million tons of MSW; compared to 2010, there was an increase of 3,7% (from about 35.6 to about 36.9 million tonnes). Considering the number per capita, are sent to composting 73 kg/inhabitant per year of MSW, an increase of 2 kg/capita compared to 2010.

2.2 Italian contest

The national production of municipal waste amounted, in 2011, to just under 31.4 million tons, registering a reduction of almost 1,1 million tons compared to 2010 (-

3,4%). Preliminary data for the year 2012 show a further decline of about 4,5% compared to 2011. The overall reduction in the last two years is, therefore, is equal to 7,7%, corresponding, in absolute terms, to 2.5 million tons.

The course of the production of urban waste is, in general, consistent with the trend of socio-economic indicators such as gross domestic product and household consumption.

The analysis of the production data of municipal waste in the macro area level shows, between 2010 and 2011, a percentage decline of 4,2% for the Centre and 3., for both the North and the South. In absolute terms, the quantity of MSW produced in 2011 amounted to more than 14,3 million tonnes in the North, 7 million tons to 10 million tons in the Centre and 10 million tons in the South.

With regard to the production per capita (Table 2.1) it is observed between 2010 and 2011 a reduction at the national level of 8 kg per inhabitant per year, corresponding to a decline of 1,5%.

Table 2.1. *Production of municipal waste per capita by region, years 2007-2012. Source ISPRA; population data: ISTAT*

Regione	Popolazione 2012	2007	2008	2009	2010	2011	2012
		(kg/abitante* anno)					
Piemonte	4.357.663	516	508	505	505	495	465
Valle d'Aosta	126.620	601	608	621	623	618	605
Lombardia	9.700.881	512	515	501	500	497	477
Trentino Alto Adige	1.029.585	486	496	501	491	507	491
Veneto	4.853.657	491	494	483	488	475	456
Friuli Venezia Giulia	1.217.780	506	497	479	494	472	452
Liguria	1.567.339	610	612	605	613	612	586
Emilia Romagna	4.341.240	673	680	666	677	672	637
Nord	**27.194.765**	**539**	**541**	**530**	**533**	**527**	**503**
Toscana	3.667.780	694	686	663	670	646	614
Umbria	883.215	639	613	590	597	573	553
Marche	1.540.688	564	551	537	535	533	520
Lazio	5.500.022	604	594	587	599	603	582
Centro	**11.591.705**	**630**	**619**	**604**	**613**	**605**	**582**
Abruzzo	1.306.416	527	524	514	507	506	480
Molise	313.145	404	420	426	413	423	404
Campania	5.764.424	491	468	467	478	458	443
Puglia	4.050.072	527	523	527	525	517	489
Basilicata	577.562	414	386	382	377	381	371
Calabria	1.958.418	470	459	470	468	458	442
Sicilia	4.999.854	536	526	516	517	516	485
Sardegna	1.637.846	519	507	501	492	485	456
Sud	**20.607.737**	**508**	**496**	**493**	**495**	**486**	**463**
Italia	**59.394.207**	**546**	**541**	**532**	**536**	**528**	**504**

The reduction in the amount per capita would seem much more contained compared to that detected by the given absolute production. In fact, the per capita value significantly

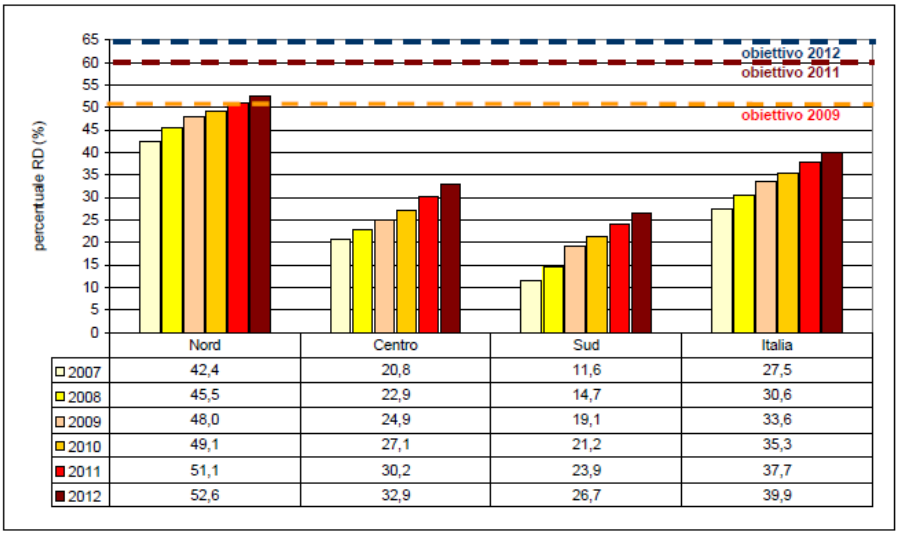
affects the performance of the given population, points out that between 2010 and 2011 a decline of the resident population of nearly 1,2 million units.

As for the separate collection of municipal waste the Legislative Decree n. 152/2006 and the Law of 27 December 2006, n. 296 identifies the following targets of collection:

- at least 35% by 31 December 2006;
- at least 40% by 31 December 2007;
- at least 45% by 31 December 2008;
- at least 50% by 31 December 2009;
- least 60% by 31 December 2011;
- at least 65% by 31 December 2012.

It should also be pointed out that the Waste Framework Directive 2008/98/EC, transposed into national law by Legislative Decree n. 205/2010, side by side, the collection targets required by Italian regulations, target preparation for reuse and recycling targets for specific waste streams such as municipal waste and waste from construction and demolition.

The amount of municipal waste collected separately reaches, in 2011, a percentage equal to 37,7% of national production, reaching more than 11,8 million tons (Figure 2.4). Compared to 2010, you notes a further growth that does not allow to achieve the objectives set by the regulations for 2009 (50%) and 2011 (60%).

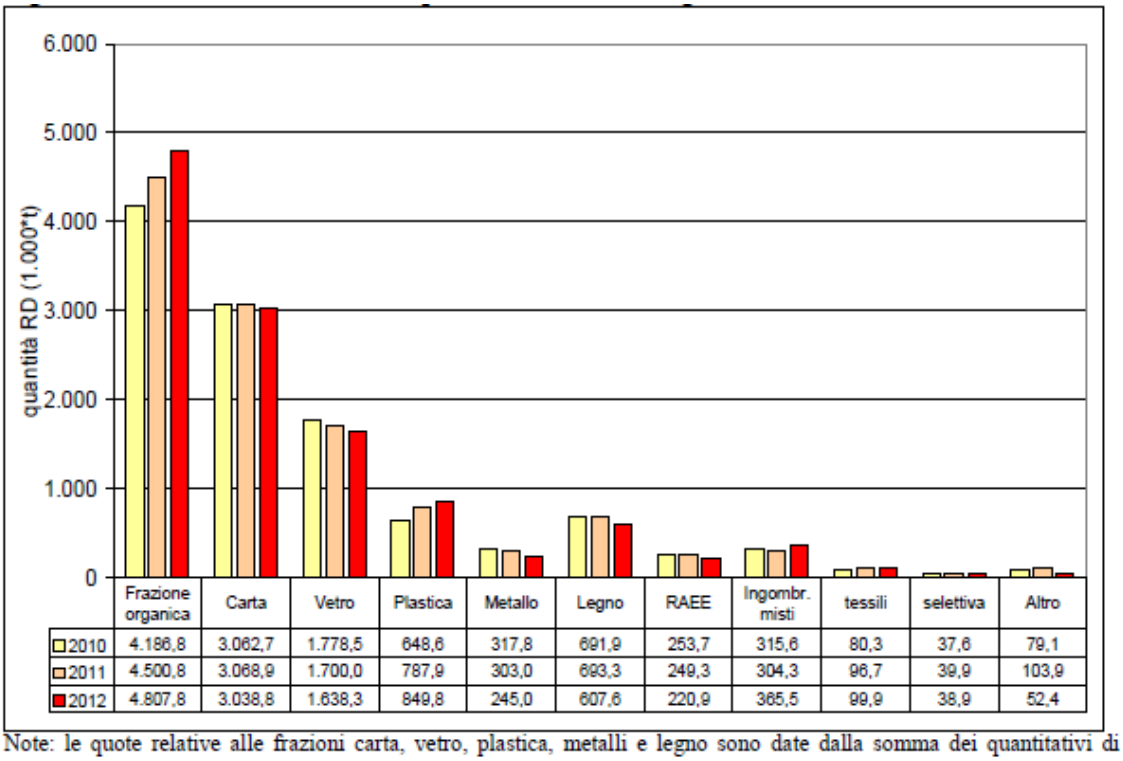


	Nord	Centro	Sud	Italia
2007	42,4	20,8	11,6	27,5
2008	45,5	22,9	14,7	30,6
2009	48,0	24,9	19,1	33,6
2010	49,1	27,1	21,2	35,3
2011	51,1	30,2	23,9	37,7
2012	52,6	32,9	26,7	39,9

Figure 2.4. *Trends in the percentage of separate collection of municipal waste, years 2007-2012. Source ISPRA*

In the North the percentage of recycling stood at 52,6%, at the centre to 32,9%, while the rate for the South stands at 26,7%. On a national scale, the percentage is 39,9%.

Examination of Figure 2.5 shows, between 2010 and 2011, an increase of 7,5% of the collection of organic waste (wet+green), which follows the rise of approximately 11,8% recorded between 2009 and 2010.



	Frazione organica	Carta	Vetro	Plastica	Metallo	Legno	RAEE	Ingombr. misti	tessili	selettiva	Altro
2010	4.186,8	3.062,7	1.778,5	648,6	317,8	691,9	253,7	315,6	80,3	37,6	79,1
2011	4.500,8	3.068,9	1.700,0	787,9	303,0	693,3	249,3	304,3	96,7	39,9	103,9
2012	4.807,8	3.038,8	1.638,3	849,8	245,0	607,6	220,9	365,5	99,9	38,9	52,4

Note: le quote relative alle frazioni carta, vetro, plastica, metalli e legno sono date dalla somma dei quantitativi di imballaggi e di altre tipologie di rifiuti costituiti da tali materiali. Dati 2012 provvisori.

***Figure 2.5**. Separate collection for possession of goods, 2010-2012. Source ISPRA*

Between 2011 and 2012 there is a further increase of 6,8%, which brings the national data collection plan at a value of more than 4,8 million tons. An increase of 21,5% between 2010 and 2011 and to 7,9% between 2011 and 2012, it is noted for the collection of plastic that came in the two reference years, about 788 thousand tonnes and 850 thousand tons, respectively. The other product fractions have instead maintained almost constant their values.

In the peninsula landfilling is still the most common form of management affecting 42,1% of municipal waste. The recycling of the different fractions from the separate collection by plants or mechanical biological treatment of municipal waste accounts for 34,4% of the production of which 11,6% is the only organic fraction from RD (wet + green) and the 22,8% from the remaining product fractions.

In 2011, the disposal in landfills, amounting to 13,2 million tonnes of waste decreases compared to 2010, of more than 1,8 million tons (-12.1%), mainly attributable to the decrease of the production of waste. The waste incinerated increased by 1,4% between 2010 and 2011; there is, however, a decline in the next two years (-3.7%), due in this case to the decrease of the production of waste.

Between 2010 and 2011 increases the amount of waste sent to mechanical biological treatment (+3.3%) and the organic fraction started to aerobic and anaerobic biological treatment (+1%). Composting affects about 3.5 million tonnes of municipal waste and anaerobic digestion almost 450 thousand tons of municipal waste. The recovery of other waste types in the same period rose from more than 6,4 million tonnes to 7,3 million tonnes, registering a growth of 13,6%. Figure 2.6 shows the percentage distribution of the different forms of management in 2011.

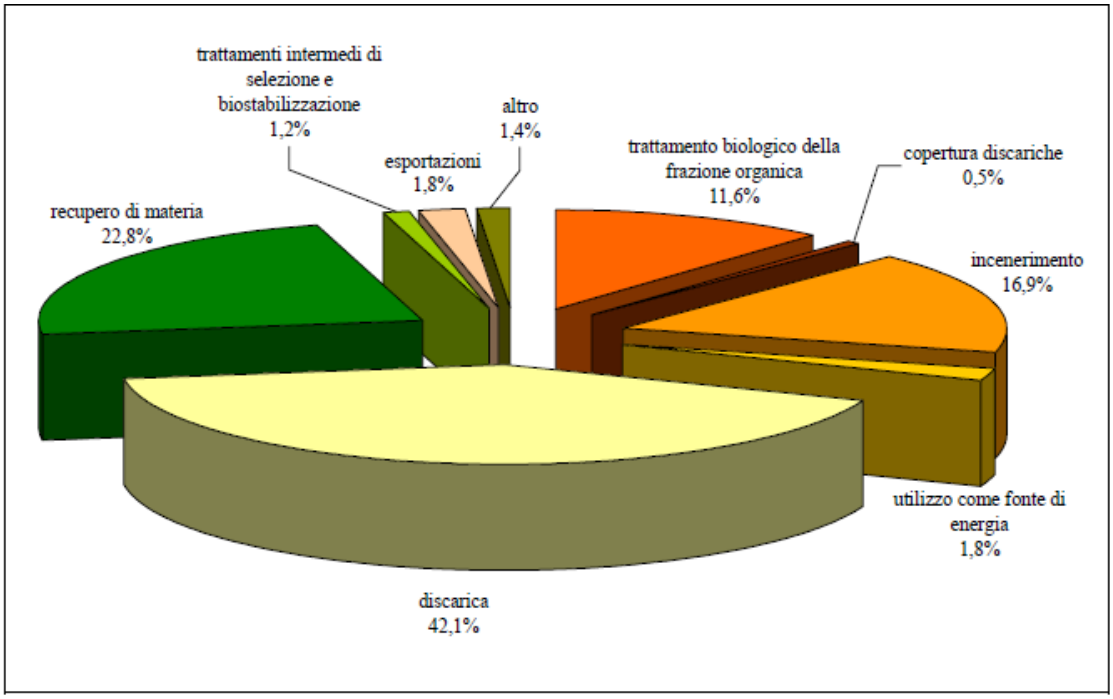


***Figure 2.6**. Percentage distribution of urban waste management, Year 2011. Source ISPRA*

Nationally, more than half of the waste (53%) are disposed of without being subjected to any form of pre-treatment.

2.3 Sicilian contest

Consistent with the data recorded on a national scale and macro area, is observed between 2010 and 2011, an overall decline of regional production of municipal waste, with the exception of the Trentino Alto Adige and Molise. Analysing the data in the 2012 in Sicily there has been a drop in production compared to 2011 by 6,1%.

The average production of waste in Sicily (516 kg*inh/year in 2009) practically coincides with the national average (532 kg*inh/year in 2009). In the provinces of Palermo and Catania highlights the production of about 50% of the waste produced at the regional level, in line with the resident population (approximately 2350000 inhabitants) of approximately 47% of the regional total (about 5000000).

Regarding 2012, the percentage of recycling in Sicily show rates below 15%, so as the Figure 2.7 shows, very below the national target.

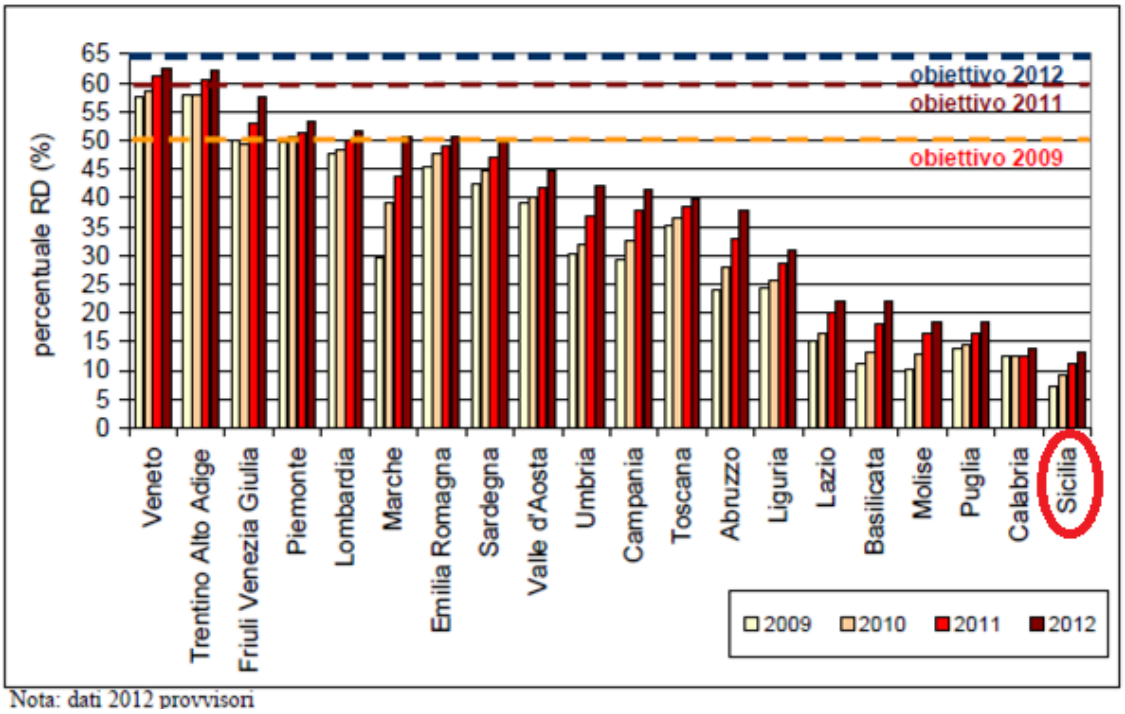


Figure 2.7. *Percentage of separate collection of municipal waste by region, years 2009-2012. Source ISPRA*

The prevailing fractions from recycling are paper for the 39%, the humid fraction (organic + green) for 18,4%, glass for 14,2% and plastic for the 8,6% .

After the slight positive trend in the period 2004-2006 the amount of waste collected separately recorded in 2007 a decrease of about half a percentage point, reaching a

value of 6.1% on a regional basis, still far from the targets regulations, as shown in Figure 2.8.

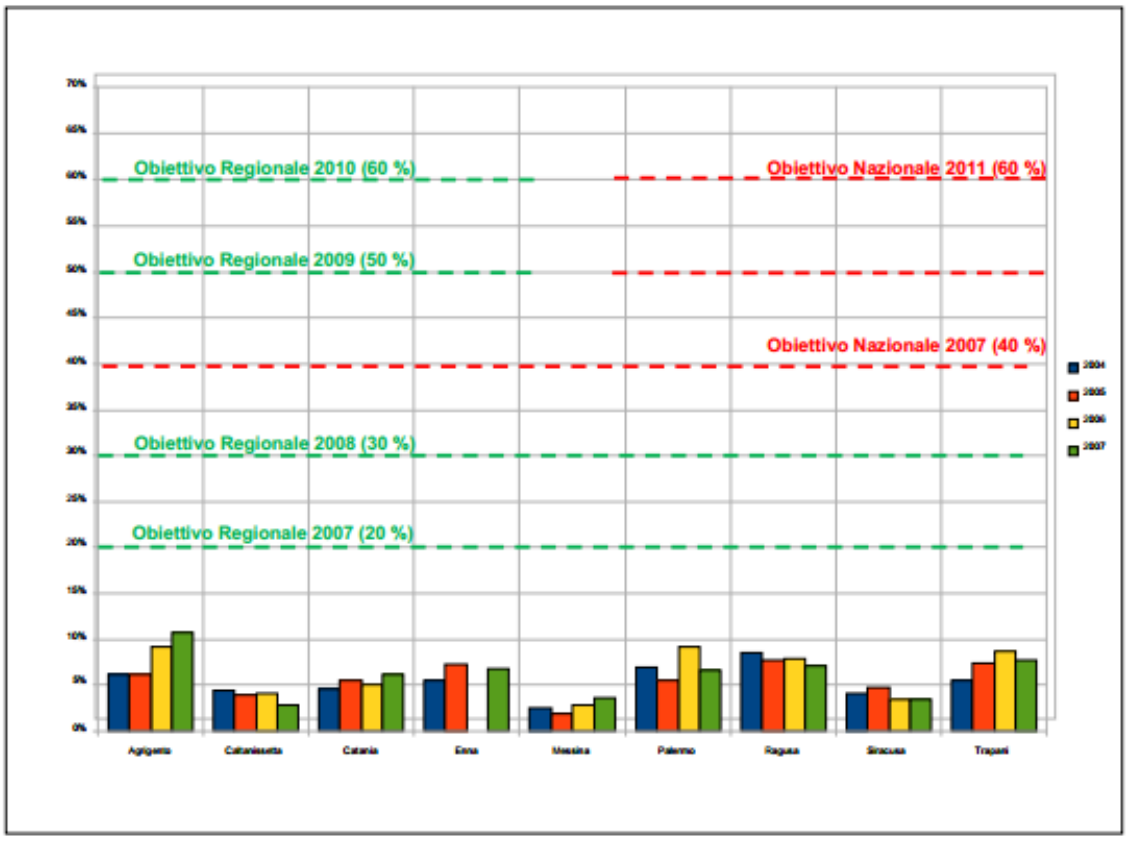


Figure 2.8. *Percentage of municipal waste collected separately for the province in the period 2004-2007 and comparison with national objectives and regional. Source: elaboration on ARPA Sicily from ISPRA data*

Figure 2.9 compares a regional level for the years 2002-2007, the amount of municipal solid waste disposed of in landfills than that produced, showing the incidence of this type of disposal.

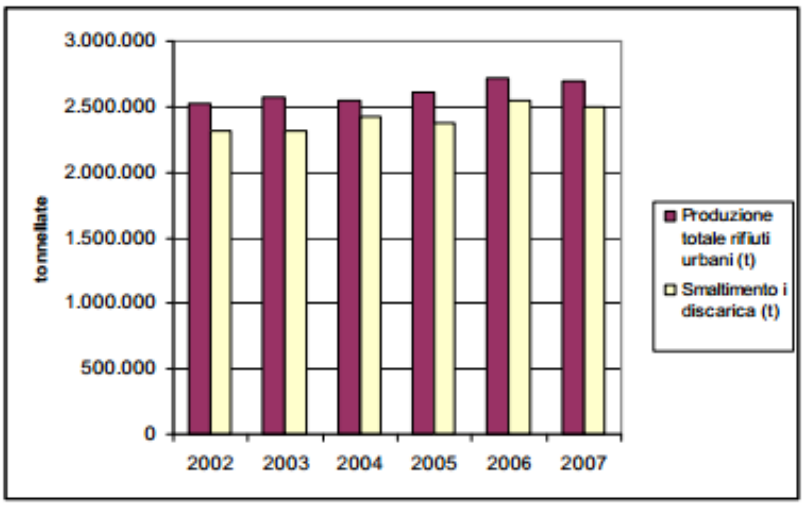


Figure 2.9. *Amount of municipal waste landfilled compared to the total produced in the period 2002-2007. Source: elaboration on ARPA Sicily from ISPRA data*

It should be noted that the number of landfills in the year to February 2010 amounted to 14 (Figure 2.10) and, therefore, is further decreased compared to 2007, when 28 plants were in operation.

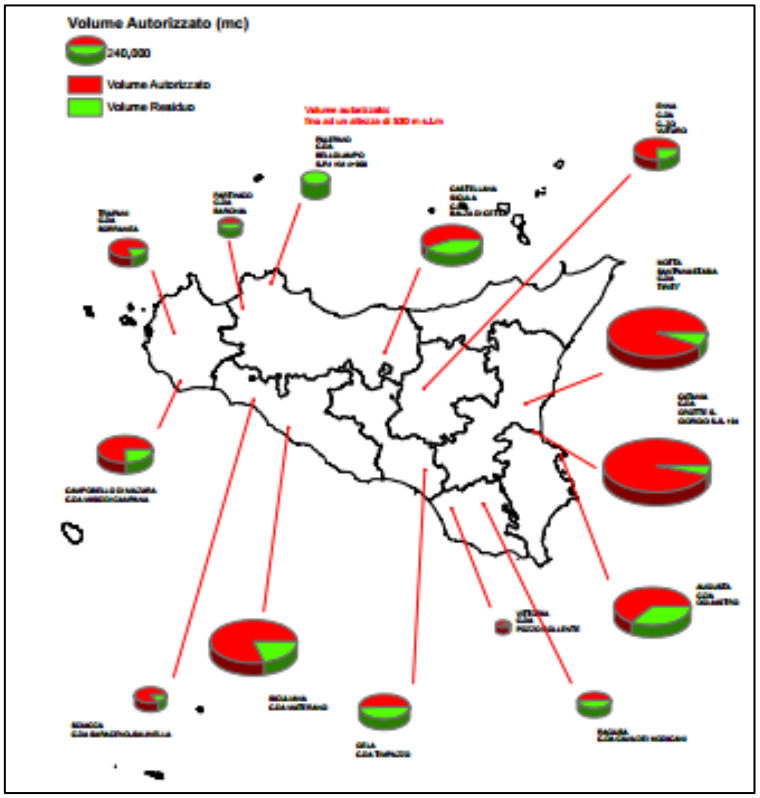


Figure 2.10. *Location of landfills in the year (February 2010). Source: ARPA Sicilia, Regional section Waste Cadastre*

Among the landfills in operation 10 are owned by public entities, while 4 individuals; compared the prevalence of public facilities, the municipalities served by private landfills are equal to 265, those served by public ones are 125.

Until December 2012, the service of waste management was entrusted to the ATO (optimal territorial areas) which were institutions (27 in Sicily) who were holding any service, from the collection of waste to landfill, the conferment of recyclable waste to the CONAI circuit, the collection of the fee Tarsu\Tia up to the collection of contributions CONAI passing from the management of ecological islands and in some cases plant owned by the Region as composting plants or platforms for the differentiation of door to door waste.

Due to the closure for the failure of Ato (supra-municipal bodies and were in total public capital) were established the Aro (Areas of optimal harvesting) and Srr (Society of waste regulation) which restore the management of the waste collection service Municipalities in the hands of the first and the second replace the old Ato:

- The Aro are the optimal collection areas and have the role of providing the service of sweeping, collection and transport, and are made up of municipalities in individual or group through the instrument of agreement between local authorities and can make action plans, tender specifications and invitation to tender for the service of sweeping, collection and transportation of waste;
- The Srr instead are all over 18 and have the role of making the area plans, costs, service standards, tariffs for this sector, monitoring services and systems planning.

Chapter 3

Municipality of Carini

The waste emergency of most of the south of Italy is also a reality of the Palermo province. With the succession of the failures due to debts of the societies which collects, transports and disposes the waste, the waste management of some towns of the province is now municipal.

The aim of the study is to investigate how the citizen of the municipality of Carini would react if the separate collection would be introduced in the municipal waste management and they should start a source segregation.

3.1 State of the art and future prospects

Carini is a town in the Province of Palermo, in Sicily; it covers approximately 76,50 km^2 and is located about 26 Km from the capital. It has a population of 38021 inhabitants (at 30 November 2013).

In the Sicilian region most of the 27 ATO have debts, and the one that was responsible of the waste management of Carini is one of this.

From an interview with the mayor of the town showed that the current management of the waste is given to the municipality by the ARO (Ambiti di raccolta ottimale). The actual management does not provide for the differential collection, so all the waste are collected together and sent to the landfill without any treatment or separation.

The landfill where the municipal waste are disposed is the one of Catania, far 230 km from Carini, but this is a momentary destination because the waste are intended to Siculiana landfill, closed at the moment due to work, which is far 177 km from the town. The nearest landfill is the one of Bellolampo, situated in Palermo, far from Carini 25 km, but the municipality of Carini did not obtain the authorization to dispose its waste there. The actual management does not work properly, with the result of a

sporadic collection that makes increase not only the waste bags on the street, but also the mice and stray animals with the consequent health hazards; the Figure 3.1 gives an idea of the actual waste situation of the municipality.

Figure 3.1. *Waste on the street in the municipality of Carini*

The future prospective, according to what was said by the mayor, is a new system managed by a new society; in fact it is awaited the approval of the city council which will be followed by a competition for a new waste management. The aims is the start of the separate collection in all the municipality in the month of July, which should bring to the 65% of collection in the 2015. The recyclable fractions should be intended in consortia present in the municipal industrial area and the residual fraction will go to the Siculiana landfill.

3.2 The familiar level

The main purpose of the thesis work is the one of establish which would be the practical reaction of a new waste management system which comprises source segregation in the municipality of Carini.

In order to do this, a sample of 20 families has been chosen, as much heterogeneous as much possible, to which a lesson of how manage a source segregation was done. Thus

each family received some paper where to add the weekly weight of the residual waste, which was collected separately from the other fractions; moreover each paper had some question with the aim to check which are their habits and if they would change in case of a better waste administration.

Since part of the population already makes a source segregation, 5 of the 20 families are used to it, while the other 15 are new to it. In order to better distinguish the two kinds of families they will be called "sample 1" the 15 families who are doing the source segregation for the first time, and "sample 2" the 5 families who did it in the past or are still doing it. Because the 20 families have to represent the overall population of the municipality, in both the samples there are different number of components, ages, style life, economic aspects and cultural and social realities.

Therefore each sample has been analysed separately from the other and then an overall result was calculated because they all part of the same municipality.

3.2.1 Initial knowledge on source segregation

A preliminary test was done in order to understand which the knowledge were before starting the analysis. The families had to answer to the question "in which bin would you get rid of the following waste if you could choose between plastic and metals, paper, glass, putrescible, residual and other", where most of waste represented the daily urban waste. Since not all the family components gave the same answers, more than 20 tests have been compiled. The so mentioned test was done to each family before explaining them how to do a correct source segregation.

Since every municipality has its own management of the separate collection (how to separate tetra-pak, disposable plastic cutlery and so on), the correct answers were referred to the brochure delivered from the municipality of Carini in the period of the collection.

The results of the test shows that most of the answers were right, with a percentage of 71,6 while the 28,4% were wrong. As the Figure 3.2 shows, everybody gave a correct answer for the vacuum cleaner bags filled and just few people wronged for the batteries for electronic devices and Mattresses and furniture; the most wronged answers were about tetra pak cartons (milk, juices, sauces ...), wood from pruning and dirty tissues.

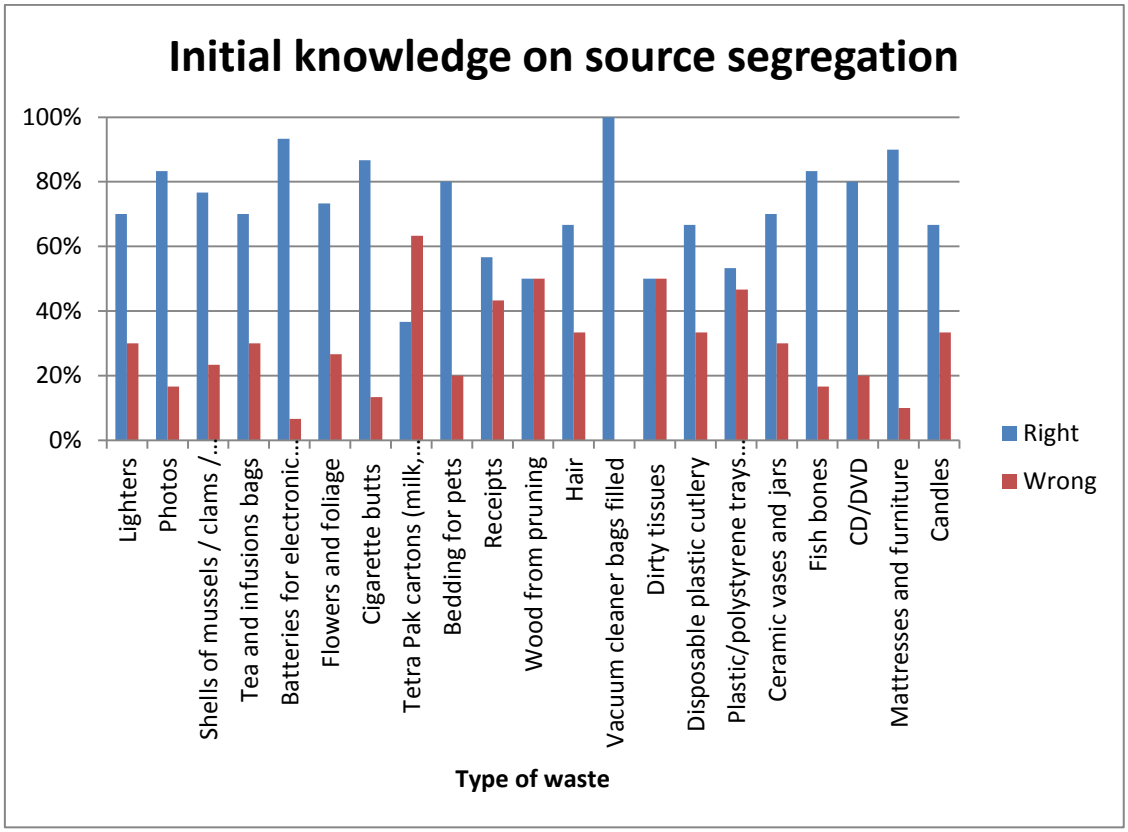


Figure 3.2. *Answers to test on the initial source segregation knowledge*

In the Table A of the appendix are presented all the data of the test answers as the percentage of the right and wrong answers.

Since the percentage of the correct answers is quite high, it is expected a good result from the merceological analysis.

After the test, the correct answers were given to the families. At the sample 1 it was explained how the source segregation works and how easily recognise in what way to differentiate the different fractions; a particular attention was given in the explanation of the residual and putrescible fractions, and also about the others, which intends eco-centre, pharmacies, authorized resellers and on call service for bulky waste, because, how the Figure 3.3 shows, this were the fraction with the highest percentage of mistakes, so the ones less clear.

At the sample 2 was asked how they did manage the source segregation and in case they did some mistake it was told them how to improve their results.

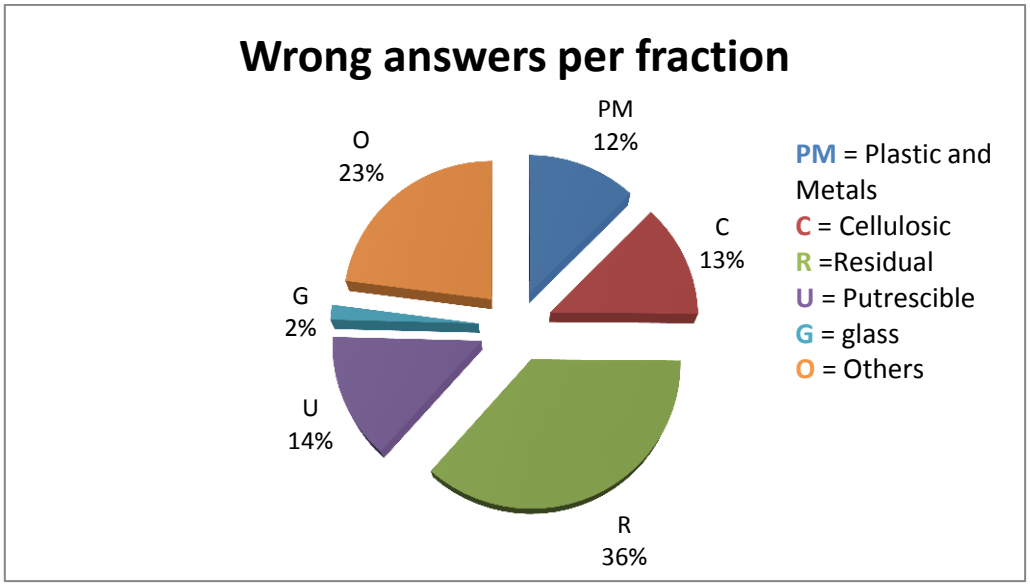


Figure 3.3. *Wrong answers per fraction to the test on the source segregation test*

Moreover, trying to simulate as much as possible the behaviour that the municipality had when made a separate collection, a paper containing the most common residual waste was given to each family; to this paper was added the sentence "if you don't know which bean choose, choose the residual one" to make them understand that the others fraction must be as much clean as possible.

3.3 Questions on the waste situation

The papers that had to be compiled had some questions about the waste manage in the houses, the habits of the families concerning the waste and their opinion about the municipal administration of it. The aim of the questions was to understand which is the behaviour of the families and if and how they would change their actions in case of a variation of the waste manage system which expect the active citizen participation.

The questions list delivered to the families are showed in the Table B. The questions were not just about the present and the future actions of the citizens, but some of them were made in order to understand the reasons of the actions, their knowledge about what compost is and how to produce it, their opinion about the waste emergency in the municipality thy live in and which they think could be the solutions to solve it.

As already said, just five families on twenty have experience with the source segregation, but not all of the five is dealing with it; in fact some of them did it while

there was the service of collection, but stopped to segregate when the collection service ended. Of the other 15 families, all of them don't do the source segregation because of the absence of collection service, considering useless doing it if "at the end all the waste goes in the same place".

Of course everybody agrees with the fact that a separate collection could solve some of the environmental problems of the municipality due to the fact that in the last period is increased not only the amount of waste on the street, but as direct coincidence also the numbers of mice and stray animals, which for sure are just the visible problems. Conversely not all the people reach agreement on who is the responsible of the actual situation, indeed most of them think that there is a common blame between a bad political leadership, the incompetence of the companies dealing of the recovery/disposal and a low diligence from the citizen all of them given by a lack of responsibility and underestimation of the problem, while others give the fault of it to the inability of the political leadership of issues correct lows about the waste problem.

At the question "which do you think may be the actions that the public administrations should undertake to make a better waste management" several answers were given, all reported in Figure 3.4.

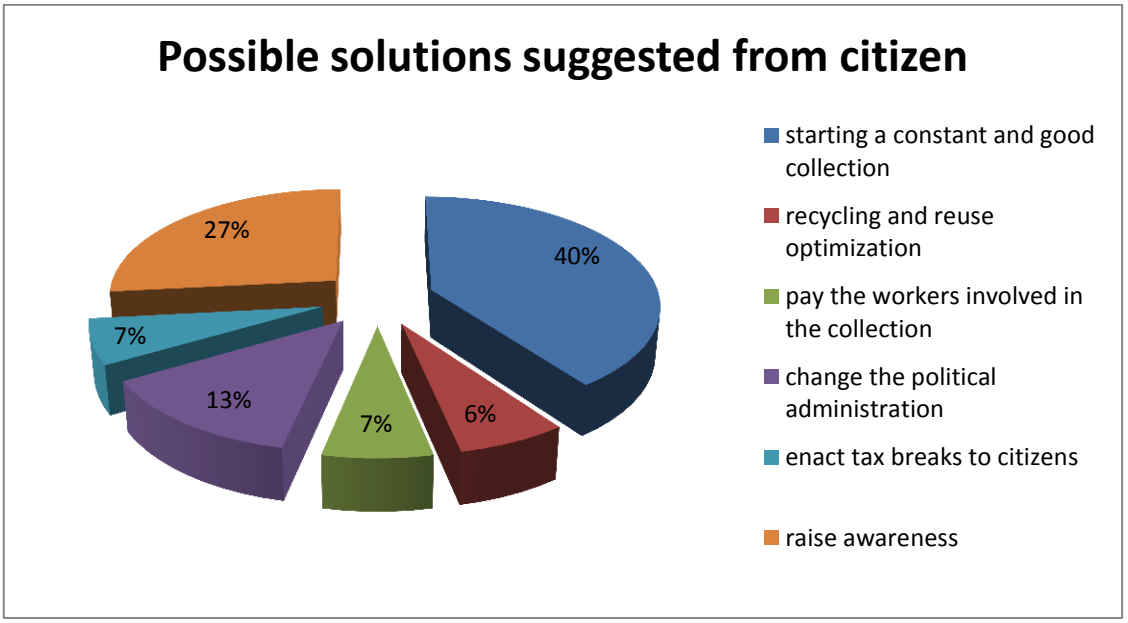


Figure 3.4. *Solution of the waste problem suggested from the citizen*

As showed in the figure above, most of the people think that starting a serious separate collection could be the solution at the problem, increased by a penalties not only to the

people who make violation of it, but also to those involved in the collection in the event of service interruption. This suggestion is for sure valid in case the citizen would participate with a effective source segregation, which, as they said, would be done from each of them in case of a door to door collection; indeed in case of collection made by the use of containers, most of them would participate, while few are not sure because the actual problems of the collection system.

In order to have a better result, they think it should be done a raise awareness which should start from the schools. According with the previous question, the people who think that the waste emergency is due to a bad political leadership consider as a good solution the change of it, which should be substituted by more competent people.

Because the citizen have their own duty it was also asked them which actions they could undertake and the answer were all about the amount of waste production, as consume less, using detergents on tap.

3.4 Weight of the refuse waste

The practical analysis was possible thanks the 20 families that collected separately the refuse waste. At both the samples was asked to collect separately the above mentioned fraction because this is the most dangerous one considering that, in case of a change in the urban waste manage, this is the part which mainly goes to the landfill.

It was useful to understand which was the amount of the residual waste, how it changed during the time, and which kind of errors the citizen do in the same fraction during the source segregation.

To have the data the families had to write the weight of the residual fraction they collected and write it down weekly for seven weeks. Moreover to understand the kind of error that was done during this period, it was necessary to analyse them, so for the first and last week it was asked to the families also to keep the waste for one whole week.

The two data, which are the weekly weight of the residual waste and the waste which were collected for two times, have been distinguished in sample 1 and sample 2, with the aim to compare the results between who knows how to ménage a source segregation and who does not.

Because waste is a “private good”, it was delivered to each family a package of ten garbage bag that they had to use to get rid of the refuse waste especially the two times

when the waste had to be hand over; in this way the bags could not be recognised and the they would remain anonymous. The only recognising sign was made in order to differentiate sample 2 from sample 1 because as already said the two analysis were made separately.

3.4.1 The data on weights

The collected data on the weights of the refuse waste produced and separated from the families are exposed in the next tables.

The waste collection was anonymous thus the families are called “fam 1”, “fam 2” and so on until “fam 15” for the sample 1, and “fam 16”, “fam 17” and so on until “fam 20” for the sample 2.

The chosen families should represent as much as possible the reality of the municipality, so there are families with different number of components in both sample 1 and 2, as showed in Table 3.1. Of course to be heterogeneous also the ages of the component are different from each family having in both the samples children, teenagers, adults and old people.

Table 3.1. *Number of components per each family of the sample 1 and 2*

Family	Components	**Family**	Components	**Family**	Components	**Family**	Components
fam 1	1	**fam 6**	4	**fam 11**	4	**fam 16**	6
fam 2	4	**fam 7**	3	**fam 12**	5	**fam 17**	1
fam 3	2	**fam 8**	2	**fam 13**	2	**fam 18**	1
fam 4	2	**fam 9**	4	**fam 14**	3	**fam 19**	2
fam 5	6	**fam 10**	3	**fam 15**	3	**fam 20**	2

In the Table 3.2 and Table 3.3 are exposed respectively the collected data of the residual waste from the sample 1 and sample 2 during seven weeks of the months of November and December.

Table 3.2. *Weight in kg of* residual *waste collected from the sam*ple *1 during the seven weeks*

	1st week (kg)	2nd week (kg)	3rd week (kg)	4th week (kg)	5th week (kg)	6th week (kg)	7th week (kg)
fam 1	0,15	0,25	0,10	0,21	0,20	0,10	0,50
fam 2	0,25	0,75	0,25	0,40	0,40	0,70	0,50
fam 3	1,03	1,16	0,28	0,16	0,36	0,42	0,31
fam 4	0,37	0,20	0,42	0,25	0,50	0,45	/
fam 5	1,30	0,60	0,70	0,50	0,80	0,60	1,40
fam 6	0,90	1,00	1,00	1,00	1,00	1,00	1,20
fam 7	0,89	0,71	0,50	1,37	0,72	2,34	/
fam 8	0,38	1,18	1,34	0,98	1,23	1,82	0,52
fam 9	0,65	1,37	0,80	0,86	1,30	1,25	/
fam 10	0,98	0,53	0,36	0,63	0,25	0,37	0,43
fam 11	0,50	0,78	1,20	0,90	1,10	0,90	0,80
fam 12	0,21	0,35	0,25	0,15	0,34	0,23	1,25
fam 13	0,90	0,26	0,28	0,43	0,30	0,23	0,26
fam 14	0,56	1,50	0,30	0,40	0,18	0,21	0,20
fam 15	0,39	0,40	0,50	0,50	1,50	0,60	1,50

Table 3.3*. Weight in kg of residual waste collected* from the *sample 2 during the seven weeks*

	1st week (kg)	2nd week (kg)	3rd week (kg)	4th week (kg)	5th week (kg)	6th week (kg)	7th week (kg)
fam 16	0,29	0,82	0,37	0,21	0,19	0,28	0,92
fam 17	0,75	0,25	0,73	0,47	0,63	1,10	0,71
fam 18	0,51	0,18	0,10	0,13	0,34	0,16	0,31
fam 19	1,20	1,30	1,70	0,70	1,20	1,50	0,80
fam 20	0,50	0,30	0,25	0,15	0,40	0,25	0,25

Some of the samples contains the symbol / that means that in that week any waste was produced, this because the family was not in the municipality in that week. The reason because this happened in the seventh week is due to the fact that the seventh week was the one before Christmas.

It is interesting to know how the waste production changes during the time. The Figure 3.5 and Figure 3.6 show respectively the refuse waste in kg produced daily per each inhabitant for sample 1 and sample 2 during the seven weeks of the months of November and December.

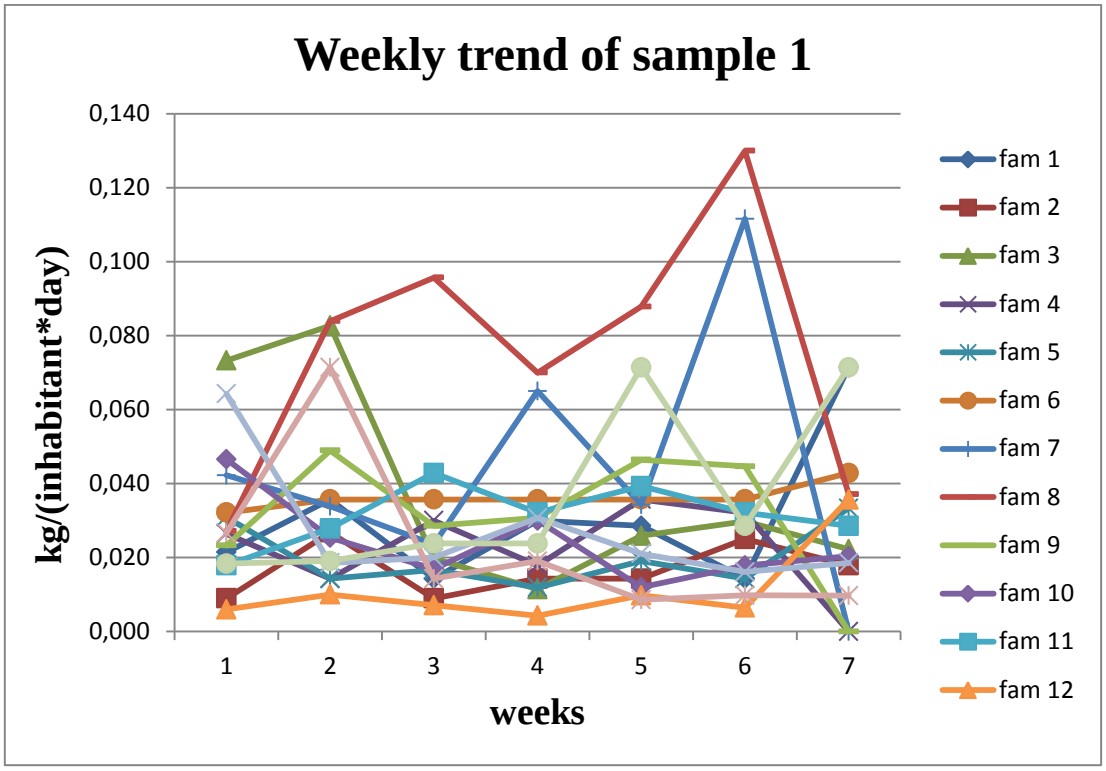


Figure 3.5. *Pro capita residual waste production of each family of the sample 1. Data obtained in November and December 2013*

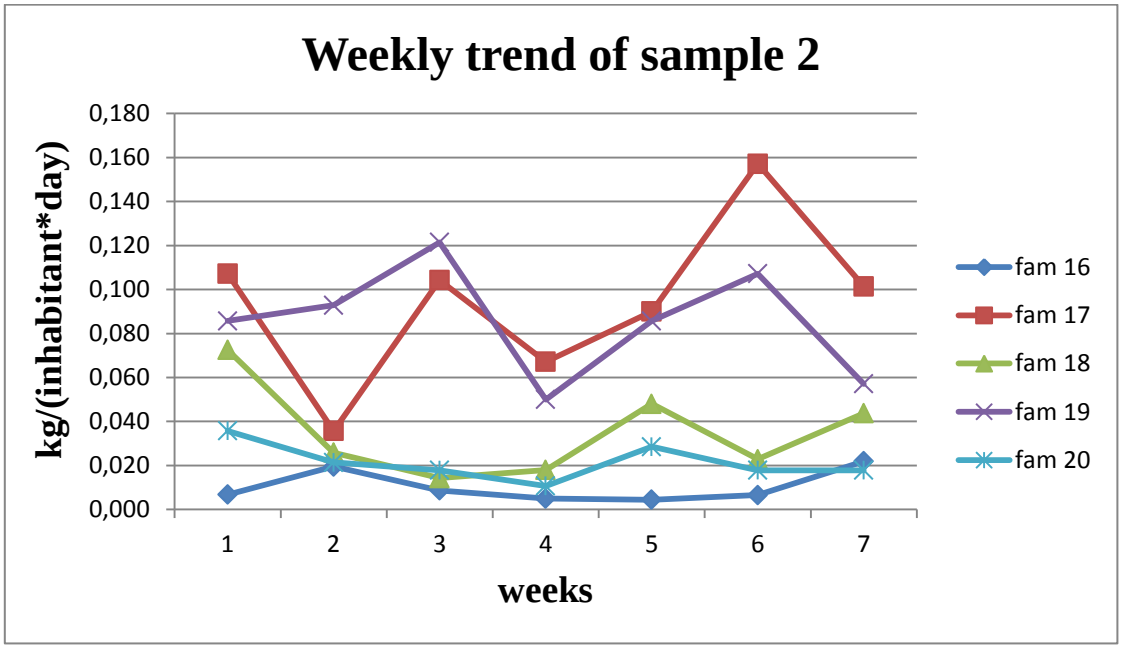


Figure 3.6. *Pro capita residual waste production of each family of the sample 2. Data obtained in November and December 2013*

Except for some pick and for some family who produces more, the drift of the refuse production is quite constant.

Given the data, it is possible to compare the trends of the mean value for each week and thus compare the daily waste production of each inhabitant for the two samples. In Figure 3.7 it is also showed the overall mean trend of the twenty families in each week (green line).

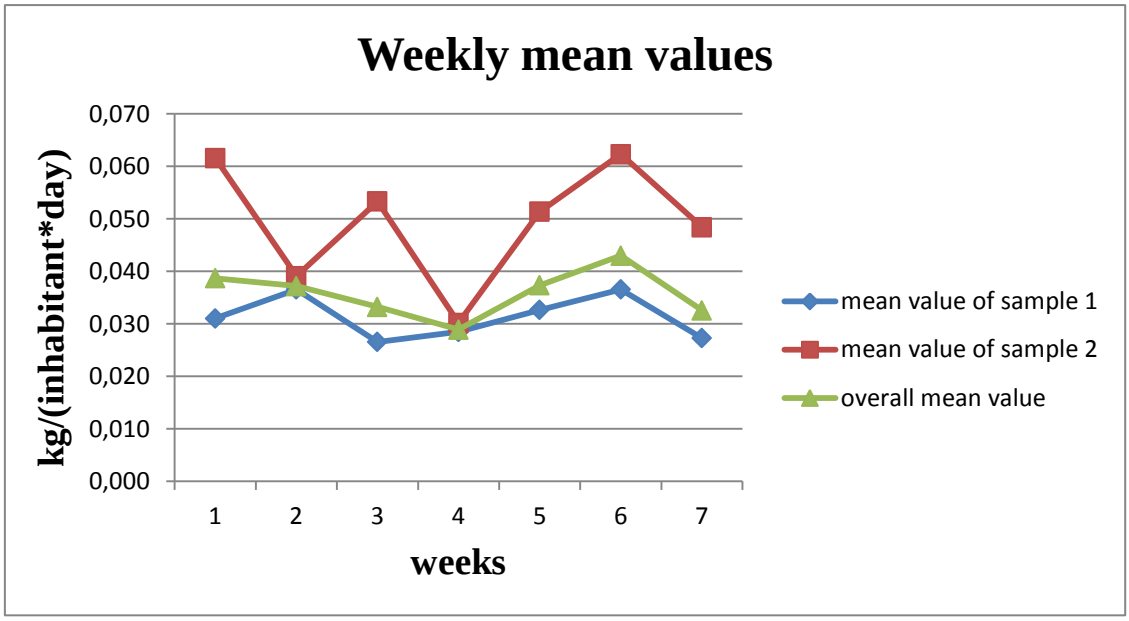


Figure 3.7. *Mean values of pro capita weekly residual waste production of sample 1 (blue), sample 2 (red) and overall (green). Data obtained in November and December 2013*

The figure shows a better trend for the sample 1, that means that weekly the inhabitants who never performed the source segregation produce a lower amount of refuse waste and in a more constant way than the inhabitants of the sample 2 do.

Chapter 4

The merceological analysis

The investigation into the waste, by merceological analysis, or materials destined for recovery, is essential for a correct qualitative and quantitative evaluation. It lets consider the material both from the point of view of the overall composition, either under an of detail aspect, through recognition of the different fractions components contributed.

4.1 Initial merceological analysis

The underlying principle that animates the current legislation is due to an integrated waste management: this means implementing a system for the recovery of municipal waste which affects the amount of residual waste by reducing the quantities to be disposed of. This requires knowledge of the potential still present in the residual waste, in terms of type and quantity of materials that may be subject to separate collection and recycling result-oriented and / or recovery.

The methodology used for the analysis is the one developed by the University of Padua in order to classify the waste also according to the size distribution. The Method IMAGE provides a sifting of the material by use of a battery of four sieves with a size of 100x70 cm, characterized by a spacing between the meshes, stacked in order of decreasing size. The analysis is performed on each oversize, and it defines underscreen everything passes by the spacing of 20 mm.

The first analysis has been made with the residual waste collected from the 20 families, as already described in §3.4. Since some of the families were already aware on how to make a source segregation, the merceological analysis have been carried out for the two different samples: the first one with the residual waste collected from the families without a source segregation experience, sample 1, and the second one with the residual waste collected from the families with a source segregation experience, sample 2.

After having collected the waste and separated the two fractions above described, they have been placed on the screening surface. The screening was done in order to get four overscreen, having used meshes respectively of 100, 75, 40 and 20 mm and an underscreen, anything that passes through the mesh of 20 mm. Once scattered around the waste on the surface and moved to allow the materials below 100 mm to filter and fall on the surface of the lower sieve, the different fractions were taken manually. The utilized screening are showed in Figure 4.1.

Figure 4.1. *Screening utilized for the merceological analysis of the residual waste*

The categories taken into account are: cellulosic, plastic, metals, putrescibles, glass and inerts, hazardous, composites. Not only the macro-categories were considered, but also the subcategories; the list of the macro-categories and their subcategories is showed in Table 4.1.

Table 4.1. *Macro-categories and subcategories taken into account during the two analysis*

<table>
<tr>
<td>CELLULOSIC MATERIALS
Newspapers & magazines
Paperboard
Kitchen paper
Textiles & Leather
Wood
Various
Sorted cellulosic</td>
<td>PLASTIC MATERIALS
Containers and bottles
Shoppers
Polystyrene
Plastic films
Dishes and glasses
Various
Sorted plastics</td>
<td>METALS
Iron cans
Aluminium cans
Aluminium various
Various metals
Sorted metals</td>
</tr>
<tr>
<td>PUTRESCIBLES
Kitchen waste
Green waste</td>
<td rowspan="2">GLASS AND INERTS
Glass materials
Ceramic materials
Stones
Sorted glass</td>
<td rowspan="2">HAZARDOUS
Batteries
Drugs
Others</td>
</tr>
<tr>
<td>COMPOSITES
Sanitary napkins and diapers
Tetra pack
Others</td>
</tr>
</table>

In the cellulosic, plastic, metals and glass and inerts fractions, the subcategories “sorted” is added because of the possibility to find dirty fractions which are not adequate for the recycle.

The so taken fractions have been weighted and the data reported. The procedure was repeated also for the following three mashes. The waste smaller than 20 mm fallowed on a separate sheet placed under the last screen, weighted and reported as underscreen.

The survey results were processed using excel sheets obtaining data relating to waste for each of the two analysis.

4.1.1 Results of the samples without source segregation skills

The methodology above described was used firstly to analyse the collected waste of the sample 1 in the month of November, the results of which are showed in the Table C of the appendix.

The amount of residual waste collected from the fifteen families of the sample 1 is 9,33 kg. It has to be considered that because the scales utilized during the analysis is different

from the once used by the families, the weight does not correspond exactly, but they are very similar; in fact making the sum of the weights written down from the families in the first week, it gives an overall weight of 9,45 kg (close to 9,33 kg).

The composition per categories of the total amount collected from the sample 1 is shown in the Figure 4.2.

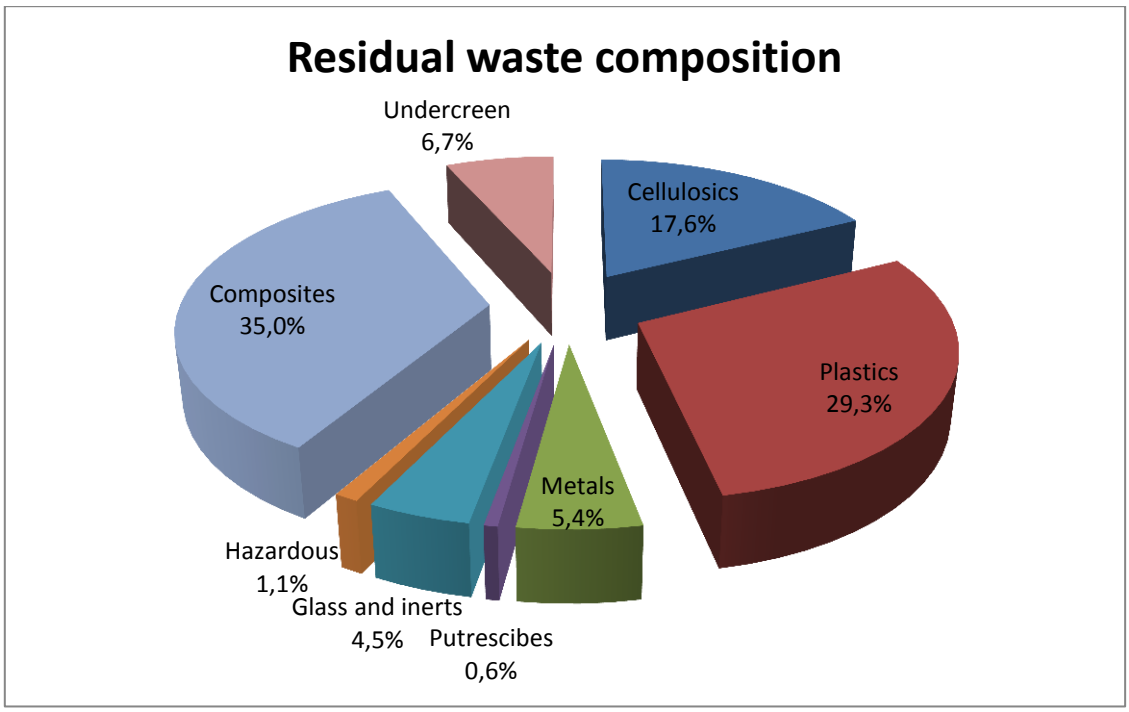


Figure 4.2. *Composition of the residual waste per each category of the sample 1 in November. The percentages are expressed on weight basis*

During the analysis the recyclable fractions have been removed from the residual material; in fact the recyclable elements are those that should be intended to a recycling facility, so in this case they represent the error in the source segregation. In the Table C the subcategories whose weights are written in red are the residual ones and their percentage are expressed in blue, while the recyclable fractions are written in black. The Figure 4.3 illustrates the percentage of the residual fraction and the recyclable ones divided per categories. It is possible to notice that of the seven categories considered during the analysis, just elements made of glass and inerts missed, while waste made of all the other kinds were present also if in small quantities.

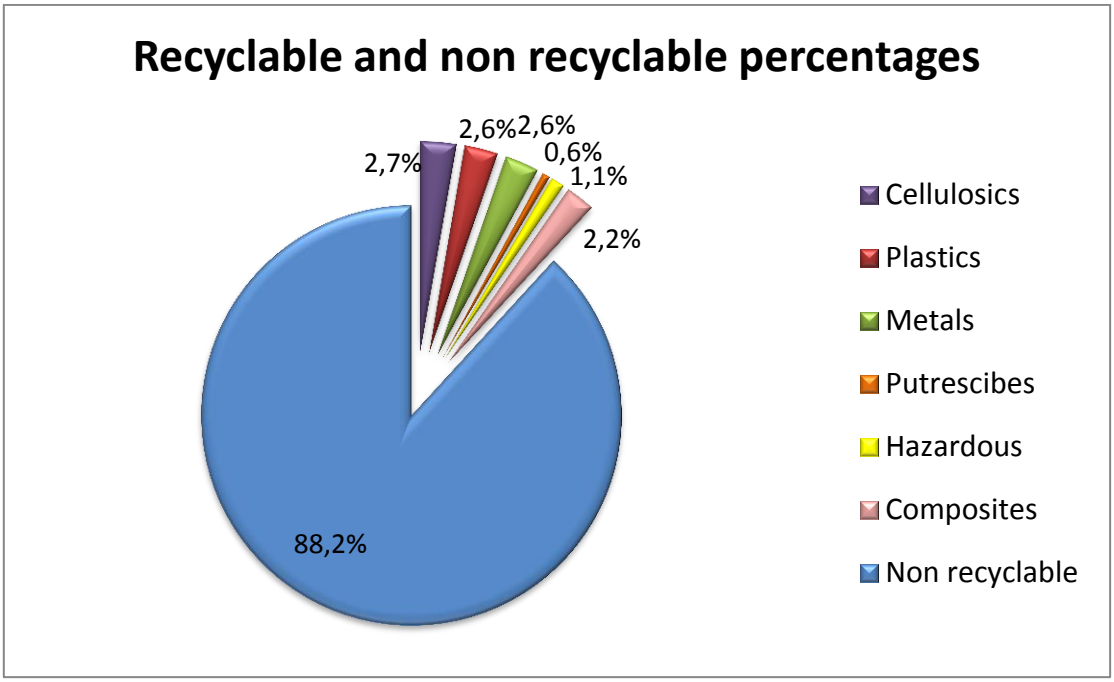


Figure 4.3. *Percentage of the recyclable and non-recyclable fractions of the sample 1 in November. The percentages are expressed on weight basis*

Comparing the two figures above it results evident that most of the fractions were mainly made of elements that were not recyclable; in fact as example the plastic materials were the 29,3% of the overall waste, but just 2,6% was recyclable. This means that the other 26,7% was made of plastic that could not be intended to the recycling because they were mainly plastic dishes and glasses. The same could be said about the cellulosic and composites fractions.

The figure above shows that the 88,2% of the residual waste collected from the sample 1 is composed by the correct fraction, while the 11,8% is made by recyclable fractions. Thus the error made from the fifteen families is very small.

By the classification in four overscreens it is also possible to underline that the 4,5% of the recyclable materials is of big dimensions (>100 mm) which means that it could be considered as a possible improvement.

The reason of a so high yield may be due to the fact that being the first time that the families made a source segregation, they paid more attention on doing it; moreover they started on carrying out the segregation after the explanation on how to best proceed. This means that once the segregation becomes an habit, the error should increase

because of the most spontaneous actions of throwing away the waste and the less care paid on it.

4.1.2 Results of the samples with source segregation skills

The methodology used for the sample 1, was applied also for the sample 2, because, having this families experiences with the source segregation, their results could be seen as a future prospective for the sample 1 once they get the same practise of the sample 2. All the collected data, and the formulations for the first analysis made for the sample 2 are present in Table D of the appendix. The residual waste produced from the sample 2 is 3 kg, data very close to the one measured by the families that corresponds to 3,2 kg; it is also interesting to notice that the families composing the sample 2 are a third of the ones composing the sample 1, and this ratio is also reflected in the amount of waste production (9,3 kg for sample 1 and 3 kg for sample 2).
The residual waste composition of the sample 2 is represented in Figure 4.4.

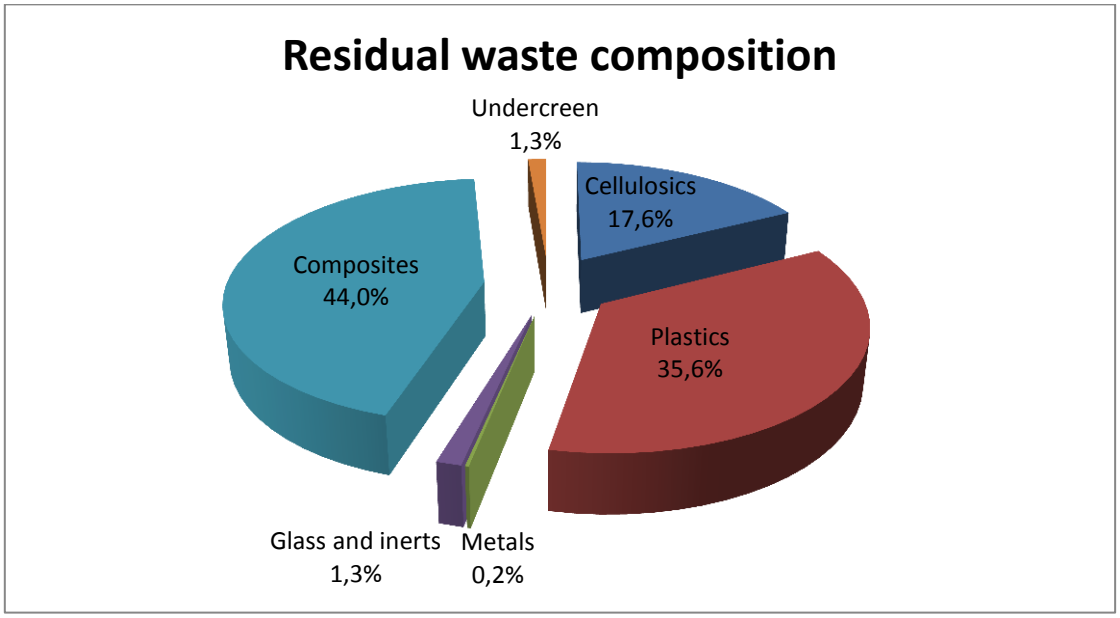


Figure 4.4. *Composition of the residual waste per each category of the sample 2 in November. The percentages are expressed on weight basis*

It shows the fractions present in the collected waste; differently than for the sample 1, in the case of the sample 2 were not present putrescibles and hazardous waste.

Because some of the fractions may contain some elements that are not recyclable, the recyclable and non-recyclable fractions were separated, in order to understand how much is the error made. This data are depicted in Figure 4.5.

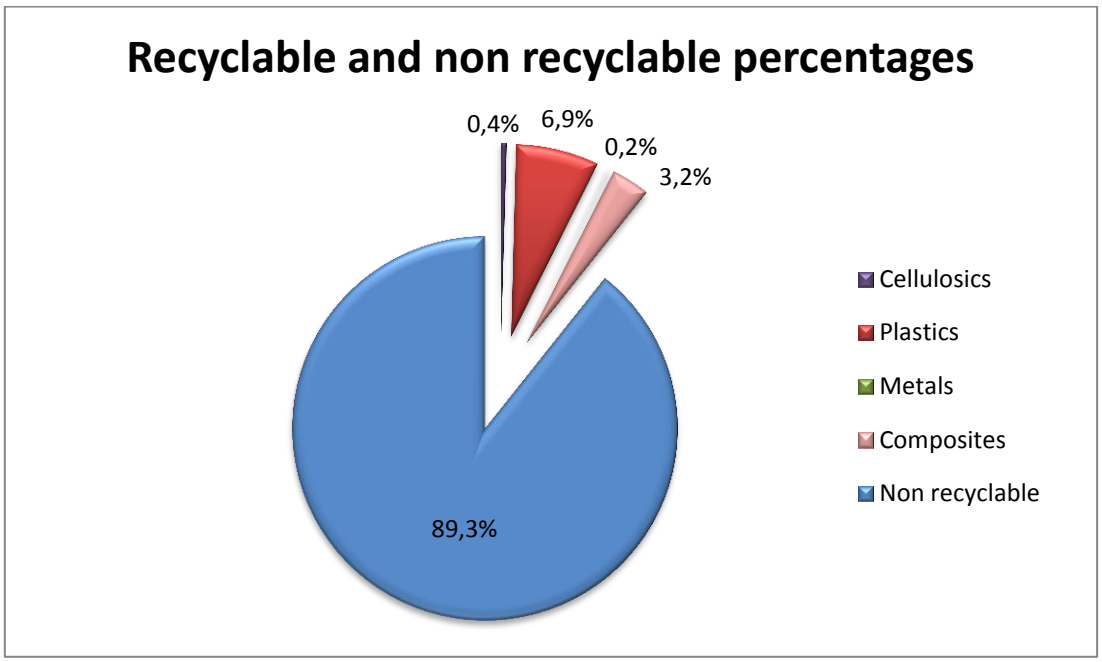


Figure 4.5. *Percentage of the recyclable and non-recyclable fractions of the sample 2 in November. The percentages are expressed on weight basis*

The first thing to notice is that, from the seven categories considered during the analysis just four of them contained recyclable waste, that, as showed in Table D, 9,7% of them were of dimensions higher than 100 mm; this means that a big part of the error could be removed by a better attention during the sorting.

Of the residual waste examined, the correct fraction was the 89,3%, so just a little error was made of 10,7%. This error was mainly made of recyclable plastic material, in particular plastic films, containers and bottles that, if easily washed can be get rid of in the plastic bin and so intended to recycle.

4.1.3 Total results

In §4.1.1 and §4.1.2 the yield of the samples 1 and 2 about the residual waste source segregation are described, but because the goal of the work is going to check which would be the reaction of the citizen to a separate collection, the data of the two samples have to be put together and they are displayed in Table E

The residual waste composition of the overall sample is given by the sum of the two samples, and, as showed in Figure 4.6, all the seven fractions are present, plus the underscreen that was largely composed from refuse waste.

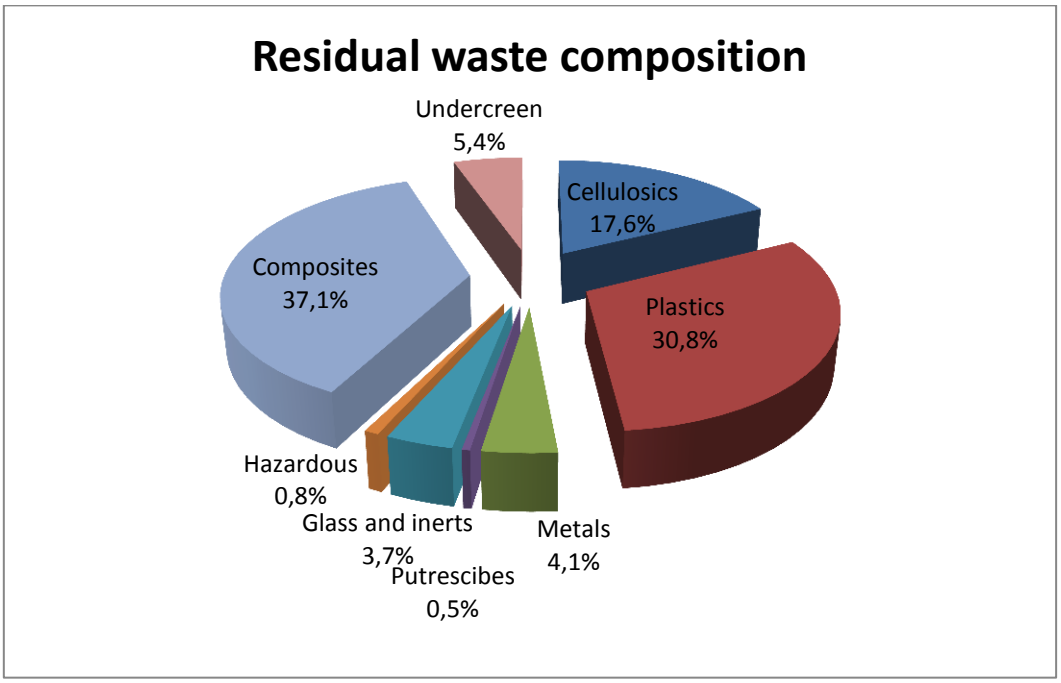


Figure 4.6. *Composition of the residual waste per each category of the samples 1 and 2 in November. The percentages are expressed on weight basis*

The figure above illustrates that more of the 80% of the tester was made of composites, plastics and cellulosic materials.

The plastic materials were composed for the 88% of not recyclable materials, as dishes and glasses and other plastics things; the remaining 12% was made of containers and bottles and shoppers, that if cleaned are recyclable.

A better yield was obtained for the composites materials, the 93% of which was made of sanitary napkins and diapers and other non-recyclable elements.

The cellulosic fraction was also big. The 6% of it was composed by paperboard and other kind of paper that could be intended to a recycling plant and other 6% was made of kitchen paper and wood that are part of the humid circuit in order to obtain compost. The remaining 88% was made of textiles and leather and sorted cellulosic, so correctly present in the refuse bin.

The other fractions were scarcely present in the test and the 23% of it were made of recyclable materials.

Taking into account the recyclable and not recyclable waste present in the test, it was possible to obtain the overall yield of the sample. The result is showed in Figure 4.7.

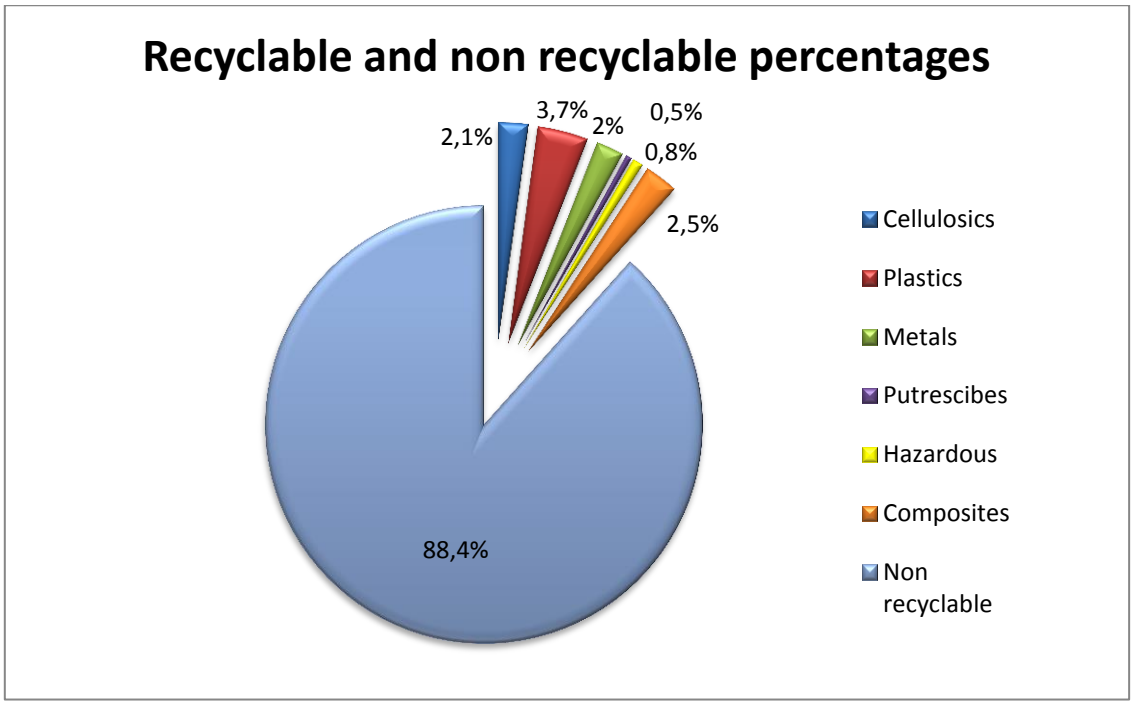


Figure 4.7. *Percentage of the recyclable and non-recyclable fractions of the samples 1 and 2 in November. The percentages are expressed on weight basis*

The overall yield was of the 88,4%, and so just the 11,6% was recyclable; 8,5% of the recyclable material was of big dimensions (>75mm), so it can be considered a possible improvement to achieve.

The only fraction that was not present with recyclable material is the glass and inerts, in fact the elements that appertain to this category that have been found during the analysis was of ceramic, so a not recyclable waste.

The global yield was very high, and this may be due to the particular attention given during the segregation from the family components. Because of this, a lower efficiency is expected during the second analysis.

4.2 Final merceological analysis and comparison with the initial one

The weighing of the refuse waste carried on for other five weeks as for the first one. At the end of the sixth week the twenty families have been contacted to inform them that the last merceological analysis would be made the following week. Thus for the last seven days they collected and kept the refuse waste.

After the first merceological analysis was concluded, the families were curious to know the results, so they have been informed about the most common errors that were found. This not only means their interest in the segregation, but also a possibility to do not find in the last test some of the recyclable waste that were present in the last test, as paperboard an containers, or more probably to find them in lower amounts.

The second analysis, that occurred in the month of December, was made in the same way and with the same instruments of the first one, in order to make a comparison as much real as much possible. Also in this case the Method IMAGE, described in §4.1 was followed. A first merceological analysis was firstly made for the sample 1, followed by the one for the sample 2; thus the data have been put together with the intention of acquire the overall result.

The reason because the analysis was made a second time, after six weeks from the first one is because with the analysis of the first week it is possible to understand which would be the immediate practical reaction of a new collection system, while with the second one gives a more real trend of the collection itself. Indeed the action of getting rid of the waste, after some weeks assumes a more routine trend, paying less attention during it, which could result in more common errors, not in quality but in quantity. The foregoing is principally valid for the sample 1, because the sample 2 has already the practice in source segregation.

4.2.1 Results of the samples without source segregation skills

Six weeks after the sample 1 started the source segregation, the separation was already a daily act. The amount of waste produced was the same of the first week, but it has to be considered that in this case the waste of three families were missing (as showed in Table 3.1) because they were not present in municipality that week. This means the production of refuse waste has increased.

Also in this case the difference between the weighted waste during the test and the one written down from the families is minimal, being respectively 9 kg and 8,9 kg due to the use of different scales.

The composition of the waste has not changed much in quality, but it has in quality; all the data of the second analysis for the sample 1 are tabled in Table F. From the Figure 4.8 compared with the Figure 4.2, it results that quantity of hazardous, composites and cellulosic materials has increased, and the one of plastics and metals has decreased. This does not mean that the efficiency of the segregation has improved or not, because the fractions could all be made of not recyclable waste. Of course this is not valid for the hazardous waste, that have never be present in the refuse waste, and the fact that this amount has increased with the time means that an information campaign on the dangers of certain kind of waste should be made.

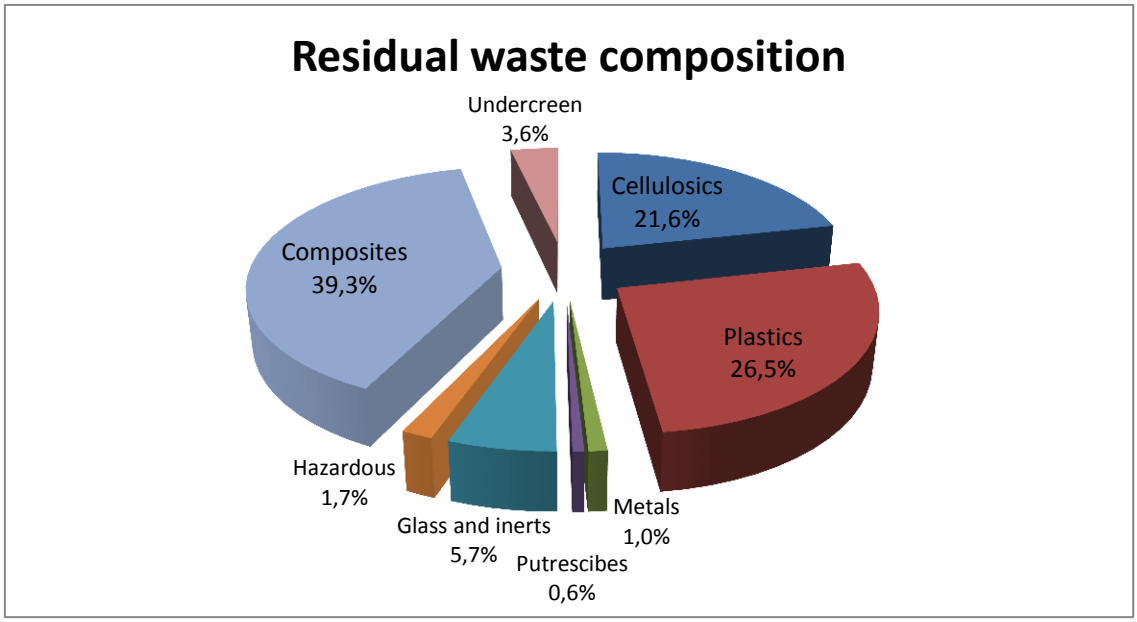


Figure 4.8. *Composition of the residual waste per each category of the sample 1 in December. The percentages are expressed on weight basis*

Considering the residual and the recyclable waste per each fraction, it is possible to obtain the efficiency in the source segregation. It is exposed in Figure 4.9.

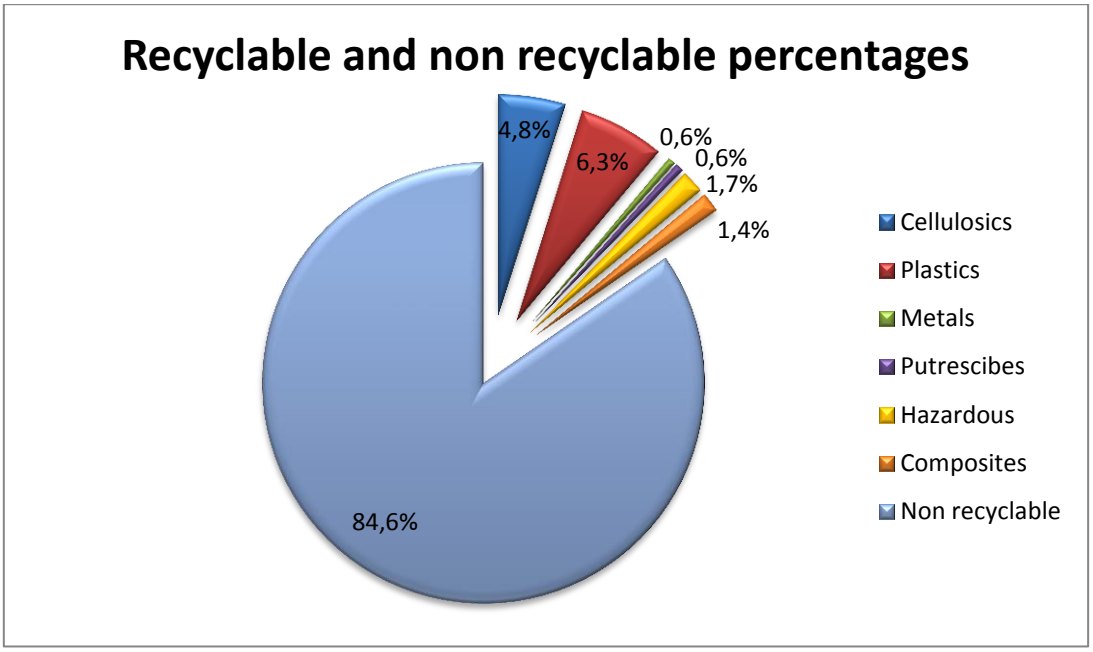


Figure 4.9. *Percentage of the recyclable and non-recyclable fractions of the sample 1 in December. The percentages are expressed on weight basis*

The quantity of not recyclable waste decreased from 88,2% in the first week to 84,6% in the last one. This means that a lower efficiency was obtained six weeks after the start of the source segregation. This result had been expected since the beginning because of the more attention the components paid during the segregation at first, that goes down with time.

The reduction in efficiency has as obvious an increase of the error in the recyclable fractions, and their amount are illustrated in Figure 4.10.

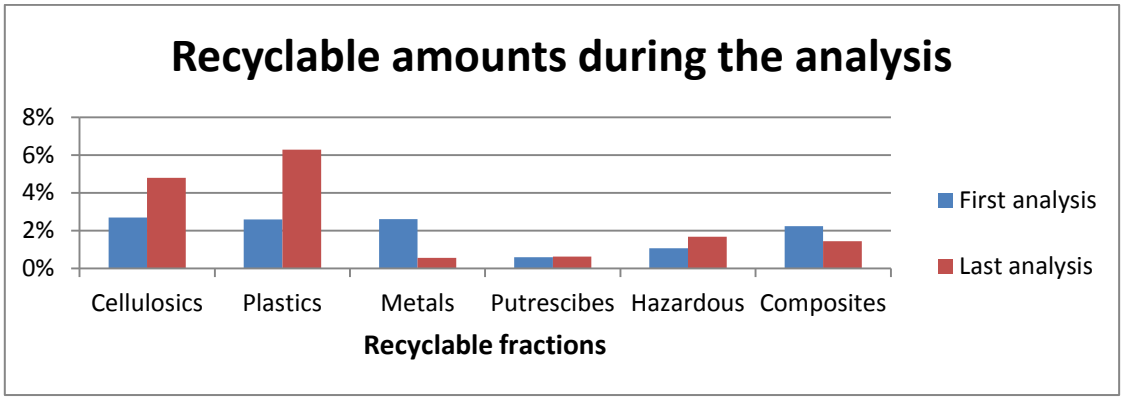


Figure 4.10. *Comparison of the recyclable fraction between the first and the last analysis for the sample 1. The percentages are expressed on weight basis*

The figure shows as in the seventh week small variations of composites and putrescible happened. The biggest differences from the two analysis are in metals, that has diminished, and cellulosic and plastics that augmented.

The cellulosic material has an higher quantity of paperboard, which essentially represent the difference between the two test as showed in Figure 4.11, while the kitchen paper and wood are not present in the test of December.

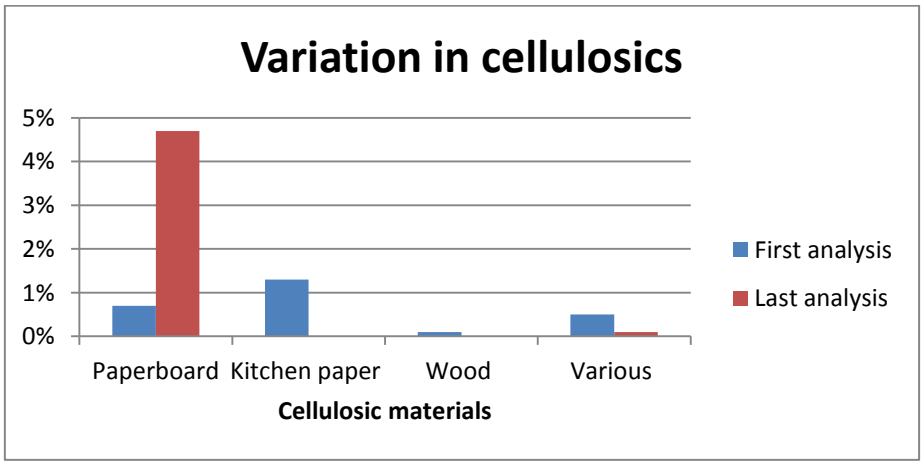


Figure 4.11. *Comparison of the cellulosic materials between the first and the last analysis for the sample 1. The percentages are expressed on weight basis*

About the plastics, the bigger differences from the two analysis are attributable to containers and bottles and other plastic elements, called various, that has increased. Some of this can be attributed to mistakes, while others to a not habit of washing

something that is a waste. Other kind of plastics did not report big variations. The comparison is exhibited in Figure 4.12.

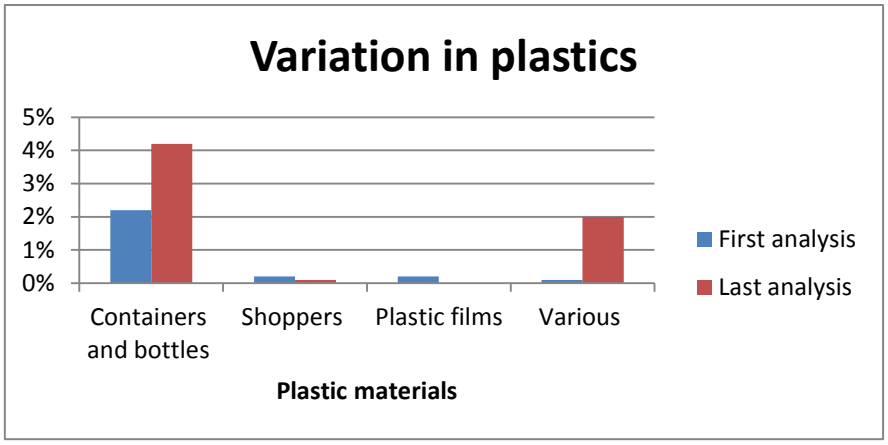


***Figure 4.12**. Comparison of the cellulosic materials between the first and the last analysis for the sample 1. The percentages are expressed on weight basis*

4.2.2 Results of the samples with source segregation skills

The expectations for the sample 2 are different from those of the sample 1; indeed, having already an habit of the source segregation, the only variation predictable are the improvement of the efficiencies or the mistakes due to momentary carelessness. The data obtained for the sample 2 are listed in Table G.

Comparing the residual waste compositions of the first week (Figure 4.4) and the one of the seventh week (figure below) it is possible to see that there are not many differences.

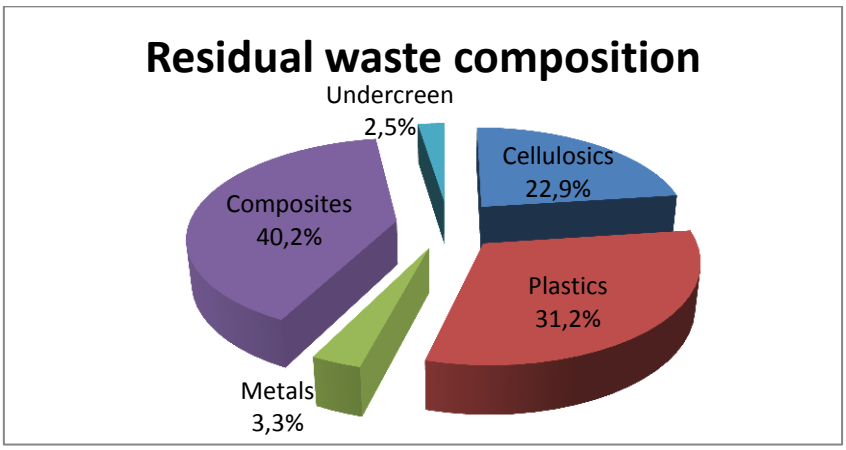


***Figure 4.13.** Composition of the residual waste per each category of the sample 2 in December. The percentages are expressed on weight basis*

In the second analysis, related to the first, the category of glass and inerts is missing. This does not means a better efficiency, because in the first analysis the category was represented by ceramic materials, which are correctly present in the fraction.
The efficiency of the test is represented in Figure 4.14.

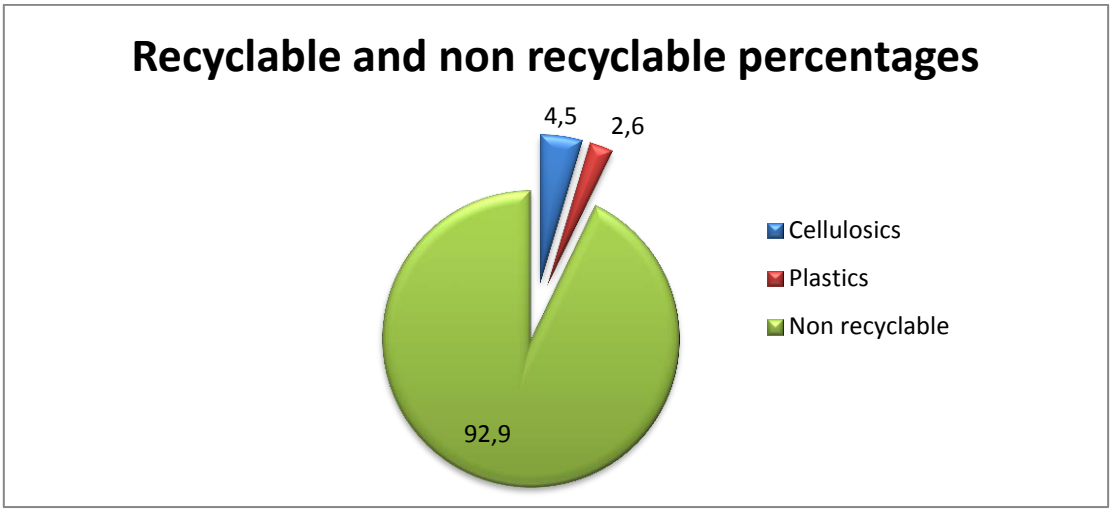


Figure 4.14. *Percentage of the recyclable and non-recyclable fractions of the sample 2 in December. The percentages are expressed on weight basis*

The efficiency in the residual waste has increased from 89,3% to 92,9%, given by a reduction of the recyclable plastics, the absence of metals and composites; however an increase of cellulosic materials was found. The comparison of the recyclable amounts is reported in Figure 4.15.

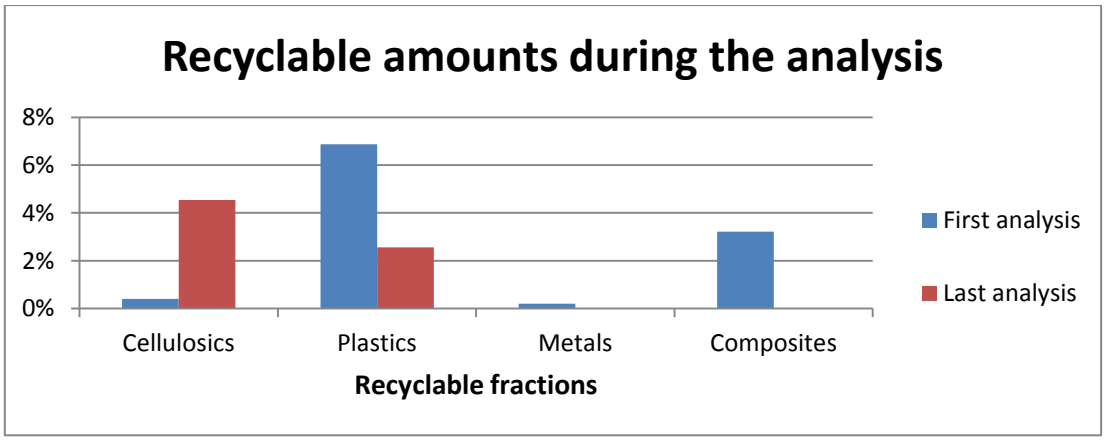


Figure 4.15. *Comparison of the recyclable fraction between the first and the last analysis for the sample 2. The percentages are expressed on weight basis*

The quantity of plastics in the refuse waste has increased just because of the lack in shoppers and plastic films during the second test; in fact no variation in containers and bottles has occurred, and a very small increase in other kinds of plastics that is so minimal that can be not considered significant. It is possible to perceive the variation in plastics in the figure below.

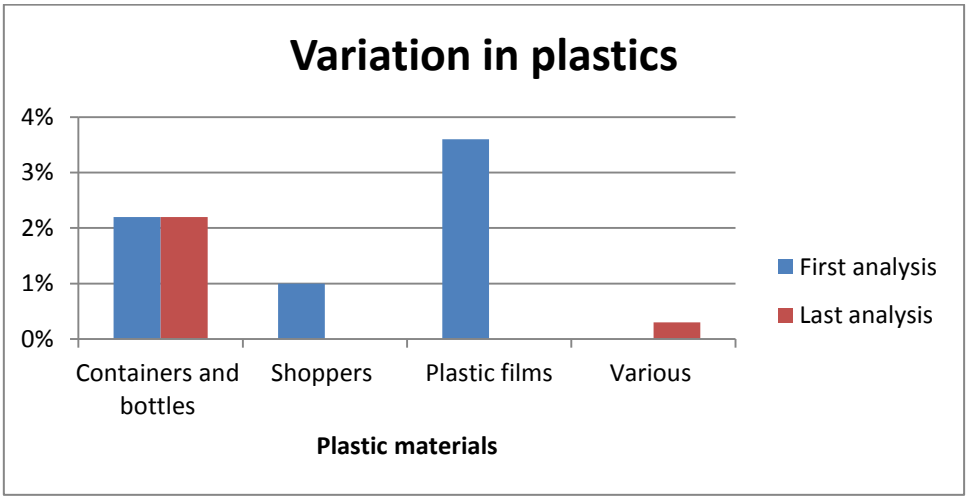


Figure 4.16. *Comparison of the cellulosic materials between the first and the last analysis for the sample 2. The percentages are expressed on weight basis*

The other big variation between the two tests is about the cellulosic compound. Figure 4.17 shows that the increase of it is caused by an increase of the 0,4% of paperboard and the introduction of subcategories that were not present in the first test, which are kitchen paper, newspapers and magazines and other kinds of cellulosic materials.

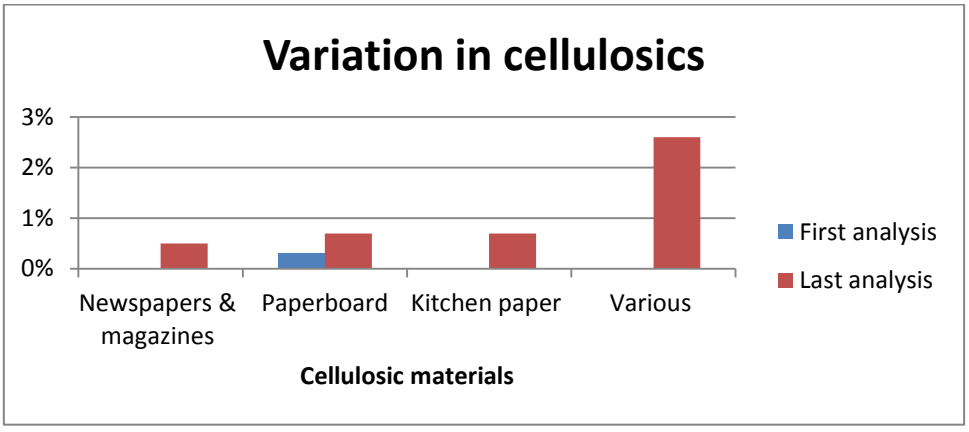


Figure 4.17. *Comparison of the cellulosic materials between the first and the last analysis for the sample 1. The percentages are expressed on weight basis*

4.2.3 Total results

The previous two paragraphs described the variation in residual waste efficiency for the samples 1 and 2 during the time. It is fundamental to understand how the overall efficiency changes with time; in order to do this, the overall residual waste composition is reported in Figure 4.18.

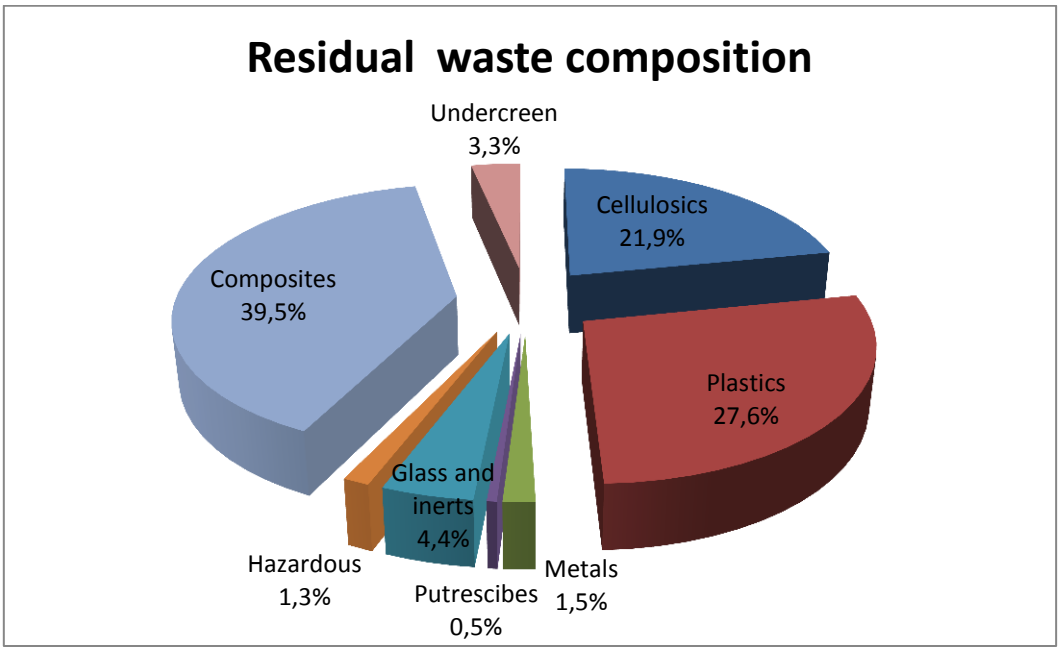


Figure 4.18. *Composition of the residual waste per each category of the samples 1 and 2 in December. The percentages are expressed on weight basis*

The variation in the overall composition, reported in Table H, reflects the ones of the two samples, with an increase of composites, glass and cellulosic amounts and a decrease of plastics and metals.

Because of the bigger diminution of efficiency of the sample 1 respect to the small increase of the one of the sample 2, an overall decrease is reported for the two samples together, from the 88,4% to the 86,6%, how it is possible to see from the Figure 4.19.

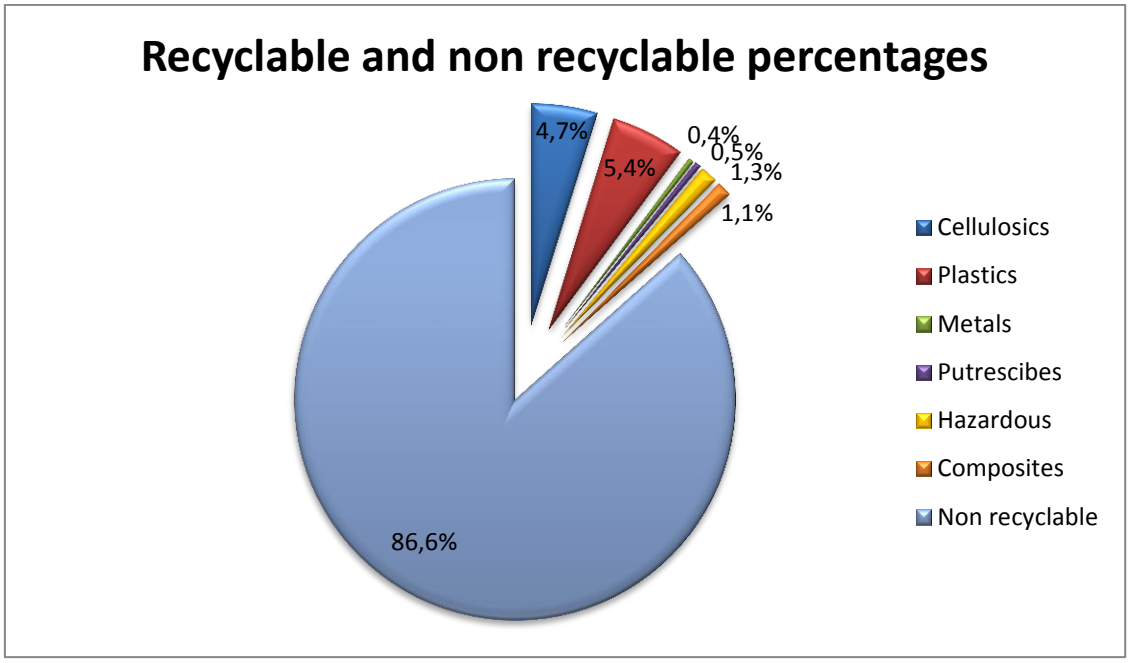


Figure 4.19. *Percentage of the recyclable and non-recyclable fractions of the samples 1 and 2 in December. The percentages are expressed on weight basis*

The decreasing of the efficiency is primarily due to an increase of cellulosic, plastic and hazardous fraction that are recyclable, and the reducing of metals and composites is not enough to oppose the overall efficiency. As describes is represented in Figure 4.20.

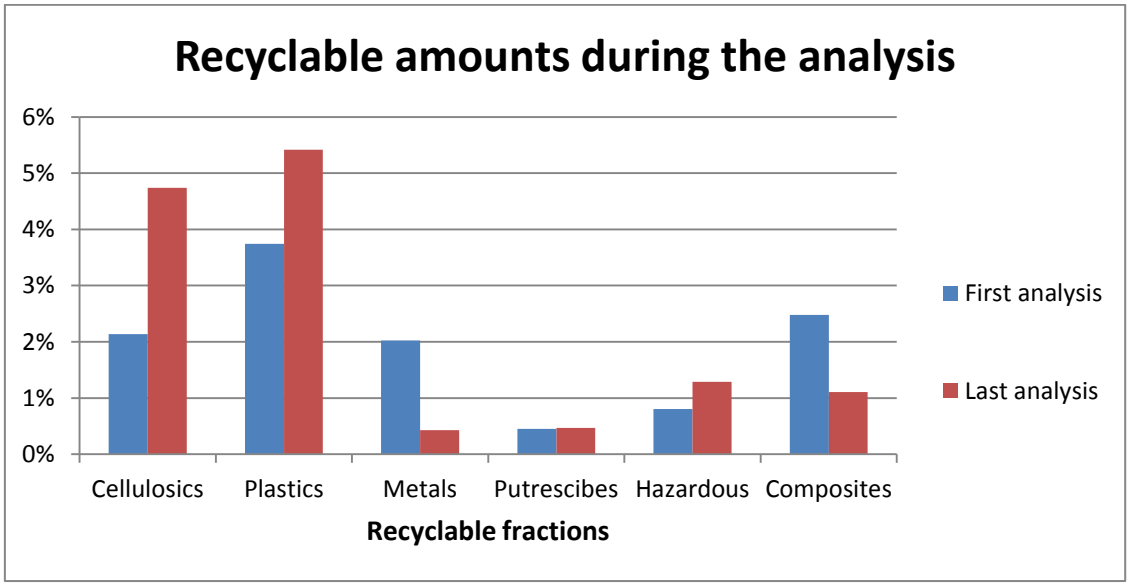


Figure 4.20. *Comparison of the recyclable fraction between the first and the last analysis for the sample 1 and 2. The percentages are expressed on weight basis*

The augmentation of the recyclable cellulosic fraction in the residual waste is given principally from the growth of the paperboard amount; in fact, as the figure below shows, the newspaper and magazines and the other kinds of cellulosic have increased minimally, while the kitchen paper and the wood have respectively decreased and disappeared.

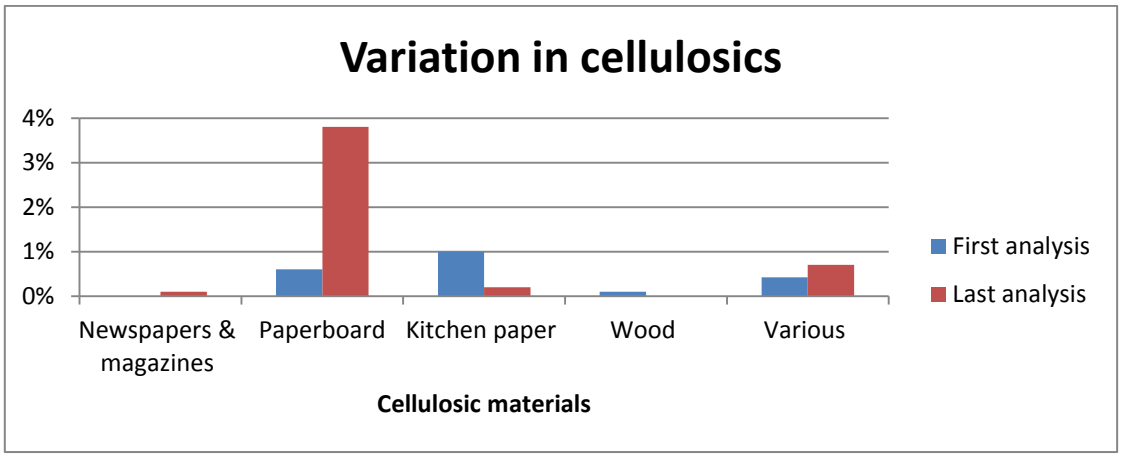


Figure 4.21. *Comparison of the cellulosic materials between the first and the last analysis for the sample 1 and 2. The percentages are expressed on weight basis*

Also if in lower percentage, the increasing in recyclable plastic fraction participates in the overall decrease of the efficiency of the residual waste. It is as a result of the growth of containers and bottles and other recyclable types of plastic, while shoppers and plastic films are negligible as the figure below shows.

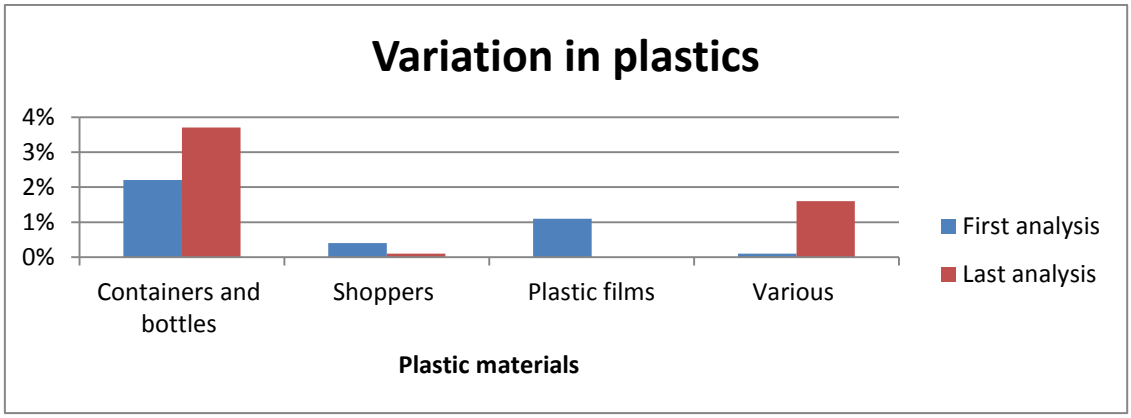


Figure 4.22. *Comparison of the plastic materials between the first and the last analysis for the sample 1 and 2. The percentages are expressed on weight basis*

The result above described were predictable, in fact a decrease of the overall efficiency during the time was expected. From the first to the second analysis six weeks passed, and surely if more time had passed the overall efficiency would have declined even until reaching more or less the national one.

4.3 Comparison whit the Quinto Vicentino analysis

The data just described refer to the initial reaction to a source segregation, in fact as seen the efficiency of the segregation decreased with time. The period between the two analysis was of seven weeks, but it is presumable that the efficiency still declines with the time.

In order to have a comparison between a reality where the source segregation was just insert, and one where the source segregation is present from 15 years, the data of the municipality of Quinto Vicentino have been taken in account and compared with the second merceological analysis of the families of the municipality of Carini.

The reason because this municipality has been chosen is that the Doctor in Environmental Engineering Carraro made the same merceological analysis with 20 families of that municipality; in this way the comparison is much realistic because the same procedure between the two analysis have been utilized.

Also if the number of components of the 20 families of Quinto Vicentino is not the same of the one of Carini, the comparison between the two can be made because it is based on the weight of residual waste produced during one week.

The residual waste compositions of the analysis made in Quinto Vicentino and Carini are showed in Figure 4.23 a and Figure 4.23 b respectively.

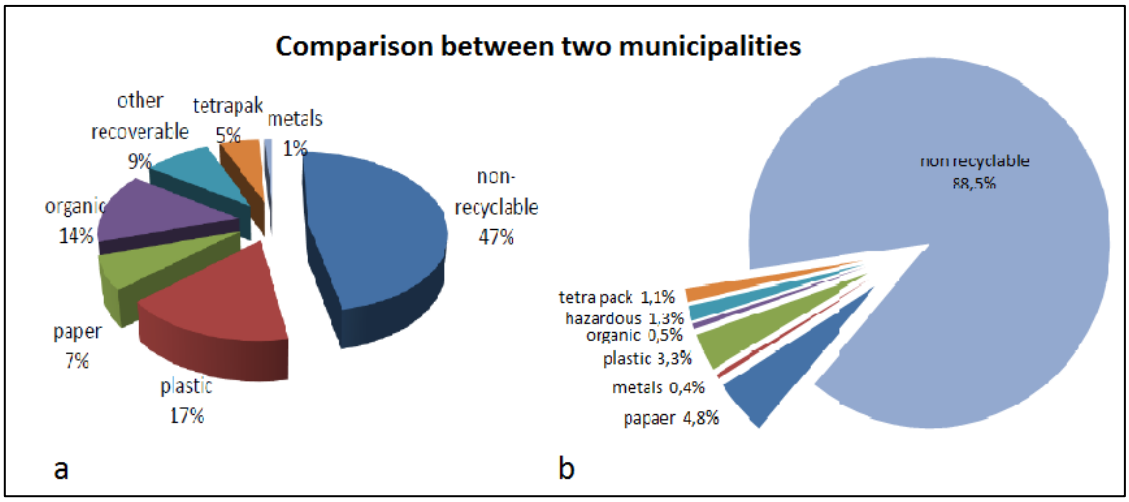


Figure 4.23. *Comparison between the merceological analysis of the residual waste of Quinto Vicentino (a) and Carini (b). The percentages are expressed on weight basis. Source Figure 4.23 a: Carraro M. (2013). Waste prevention and reduction in the municipality of Quinto Vicentino (VI). Master thesis, Padova University of Studies (Italy)*

The figure shows a big difference of efficiency between the two segregations; from the Quinto Vicentino analysis (test a from now) results that the biggest recyclable fraction is the plastic that represents the 17 of the overall test, while in the Carini municipality (test b) the biggest recyclable fraction is made by paper for the 4,8%. The amount of metals is the lowest of all the fraction in both the cases, and also small are the percentages of tetra pack. The test b results worse for the presence of hazardous material, that are the 1,3% of the test, while this fraction is not present in the test a; this may mean that with the time sample 1 maturated the concept of hazardous waste, while sample b considers the hazardous waste as any other thing they do not need anymore and want to discharge without taking into account its dangerousness.

Because of the high percentage of error made from sample a for the introduction of recyclable plastic in the residual waste, this fraction cannot taken as example for the prediction of the future behaviour of the municipality of Carini; in fact the high error n could be due to a lack of knowledge about the plastic segregation. The same cannot be said about the other fractions, in fact being the error due to the other fractions more reasonable than the plastic one, it may be considered more or less the daily error made from each citizen.

4.4 Comparison between the actual and a hypothetical modern waste management strategy

A waste management strategy that does not include fractions differentiation and disposes off all the rubbish produced by the citizen has, among others, higher costs; because of this, a primary economical evaluation is made to verify in average which are the differences in terms of costs between the actual waste disposal in the landfill, and the disposal of only the residual waste.

One consideration must be done about the landfill. As said in §3.1 the landfill where the waste of Carini should be intended is the one of Siculiana, but at the moment it is closed due to work and the waste are momently sent to the landfill of Catania; once the Siculiana landfill reopens, it will serve again the Carini municipality. Because of this, for this economical evaluation, the disposal costs taken into account are the ones of the Siculiana landfill.

According with ISPRA data obtained in 2011, the total waste production in Palermo province is 644572 tons; from ISTAT data the population of that province in 2011 was of 1243585 inhabitants, which means that every day a person produces 1,4 kg of waste.

With the actual waste management in the municipality, every kind of produced waste is sent to the landfill without any pre-treatment or treatment; being the citizen of Carini 38021 (at the 30 November 2013) every year 19707 tons of waste are disposed.

If the waste management changes and takes into account a separate collection (and as the mayor of Carini said it will happen from July 2014) what would be sent to the landfill amounts just to the residual waste; if, as the waste now, will not be treated before the disposing, the amount of waste that will be sent to the landfill every year will be 1655 tons, that is 18052 tons less every year.

Because the disposal of 1 kg of waste in Siculiana landfill costs 0,60 € the yearly saving of the only disposal (without taking into account the transport) would be 10830924 of euros. Of course it has to be considered that if the management of the waste would change taking into account also the separate collection, more costs would be added, as the costs for the collection of the recyclable fractions, treatment costs, recycle costs and so on; this means that the saving of the disposal is not a total saving, but part of this money would be utilized for a more sustainable waste management

Chapter 5

Further analysis and considerations

The high level of source segregation of the residual waste in the first week, especially for the sample 1, could be due an error in the recyclable fraction; this means that probably a part of the refuse waste could be thrown away by mistake in one of the bins of recyclable fractions. Because of this it has been decided to make a further analysis on the recyclable fraction segregated from the twenty families with the aim to understand it in that waste not recyclable categories where present. Moreover additional consideration on the reusable materials and other possible destinations of bottles taps are discussed.

5.1 Results on the recyclable fraction

To better understand which kind of error the citizen make in the segregation of the recyclable waste, in the seventh week not only it was analysed the refuse waste, but also the recyclable one per each of the two samples. Thus when it was asked to the twenty families to keep the refuse waste for the seventh week, it was also asked to save the other fractions, excluded for the humid fraction, since the impossibility to retain it home for one whole week and also the few error it usually contains.

The analysis did not considered the dimension of the waste, but only the typology of it; in fact the goal if this test was just the one to check if it contained residual waste and its amount.

The categories analysed were the same of the merceological analysis for the residual waste, that means cellulosic, plastics, metals, putrescibles, glass and inerts, hazardous and composites, but some of the subcategories partially changed, in a more accurate way, because of the necessity to have a better classification.

The categories and subcategories considered in this analysis are scheduled in Table 4.1except for the fractions of plastics and composites; in fact plastic considers bottles

and containers separately and composites have been substituted with residual waste to have a better sub-classification. This two fractions and their subcategories are listed in Table 5.1.

Table 5.1. *Subcategories of plastics and residual waste taken into account during the analysis of the recyclable materials*

Plastic materials	Residual waste
Bottles	**Sanitary napkins and diapers**
Bottles tops	**Tetra pack**
Containers	**Plastic dishes and glasses**
Shoppers	**Composites**
Polystyrene	**Other waste**
Plastic films	**Aluminium various**
Dishes, glasses, cutlery	**Cellulosic various**
Various	**Plastic various**
Sorted plastics	

In this case it was considered the category residual waste that, except for the tetrapack, contains all that waste that are not recyclable because dirty and not cleanable, as for example the pizza paperboard that in this case would be under the voice cellulosic various.

The data of the analysis are listed in Table I, Table J and Table K respectively for sample 1, sample 2 and the two samples together. To better understand it each fraction have been written with a colour, black for the recyclable fraction, red for the residual, green for the humid, blue for other kind of waste (the ones that should be intended to an eco-centre) and orange for the hazardous.

5.1.1 Results of the samples without source segregation skills

The sample 1, do not having experience with the source segregation, could have done errors due to a lack of knowledge of some kind of waste. This is the reason because the two samples have been analysed separately.

The collected data about the recyclable waste segregated from sample 1 are exposed in Table I.

The efficiency of the recyclable source segregation is very high, with a value of 95,7 %; thus the error is not due to a lack of knowledge as expected, but it is the normal one made from each citizen. The error is mainly attributable to the residual waste and fairly to the presence of putrescible materials, given from both kitchen waste and kitchen paper, that are just the 0,6% of the overall test, so it is negligible.

The total weight of the analysed test is 23 kg and its composition per each fraction of the recyclable waste segregated is represented in the figure below.

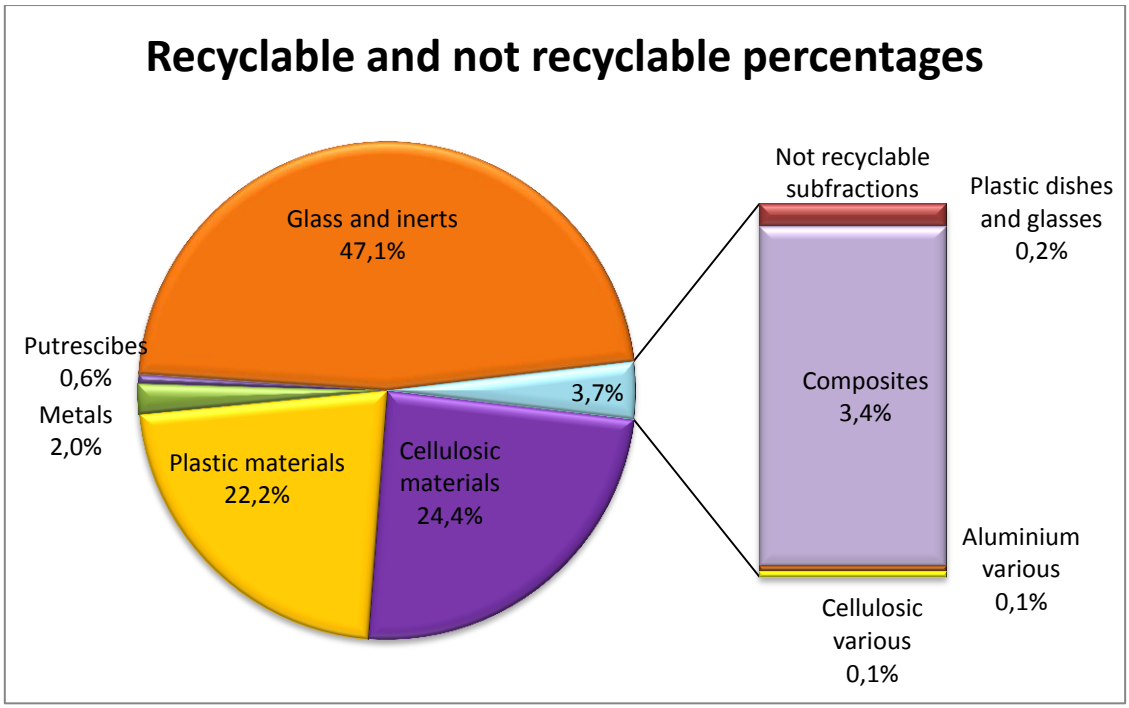


Figure 5.1. *Composition of the residual waste per each category of the sample 2 in December. The percentages are expressed on weight basis*

Of the 4,3% of the error, 3,7% is caused by the presence of not recyclable fractions, which is principally represented by composites material. Very few is the presence of dirty fraction that are not cleanable, as plastic cutlery, aluminium and paper.

The recyclable materials are all present. The biggest percentage in weight is given from the presence of glass, that represents nearly an half of the total test. Similar are the quantities of plastics and cellulosic materials, respectively 22,2% and 24,9% in weight. The plastic is mainly represented by bottles for the 56% and containers for 22,6%; few

percentages of other kinds of plastics are present as bottles tops, polystyrene and various. The cellulosic material are mostly under the form of paperboard, for the 79%; the remaining part is given by tetra pack and newspapers and magazines. Few is the presence of metals, all made by aluminium cans. To underline is the absence of hazardous waste, that for sample 1 was present in the residual waste of November and December.

5.1.2 Results of the samples with source segregation skills

The analysis of the recyclable fraction was also made for the sample 2 alone and the results of the 12 kg analysed are listed in Table J. The efficiency in the source segregation should be higher for this sample than for the one of the sample 1, but as it is showed in Figure 5.2 it is not like this.

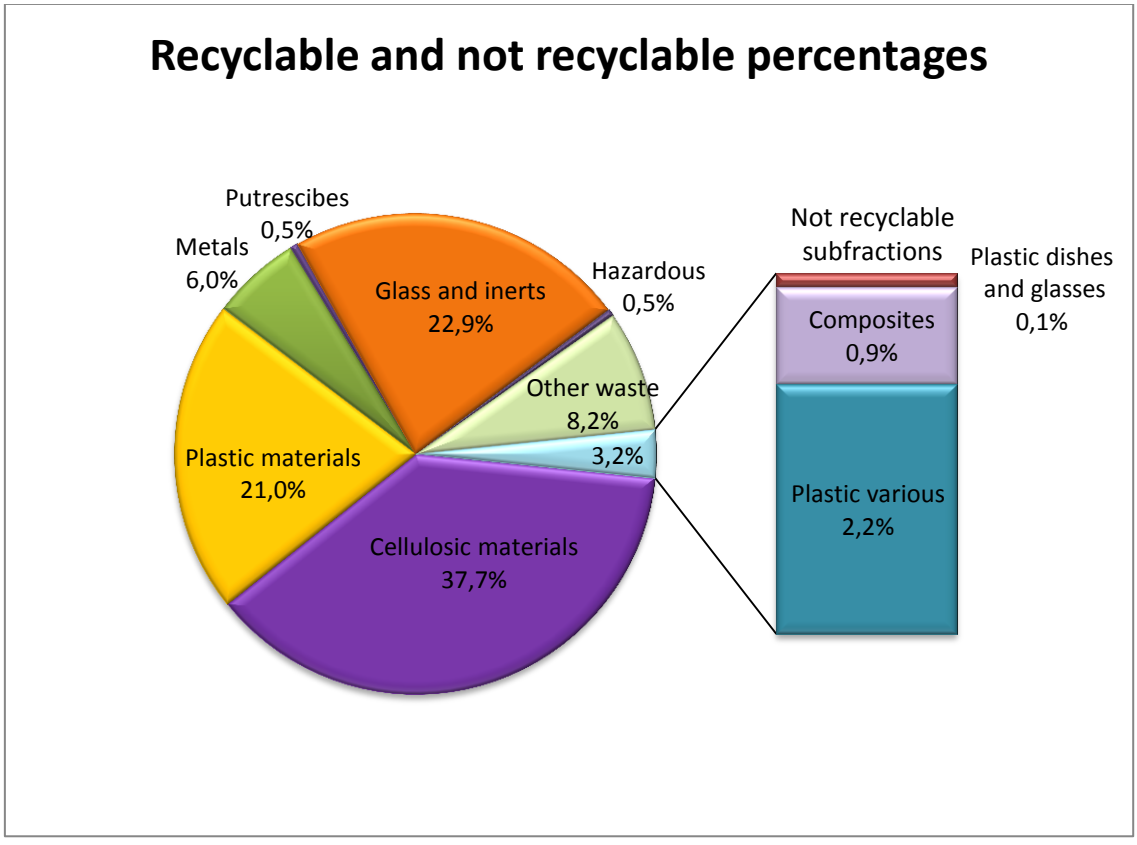


Figure 5.2. *Composition of the residual waste per each category of the sample 2 in December. The percentages are expressed on weight basis*

The efficiency of the recyclable segregation of the sample 2 is 88%, and the remaining part is made of residual, humid, hazardous and other waste.
The residual waste is largely composed from plastics that are not recyclable and also few amount of composites and plastic cutlery have been found.
Of all the not recyclable fractions the higher percentage in weight was represented from a pan, named as other waste in the figure above; it is a kind of waste that should be intended to an eco-centre, so its presence in this test is considered as an error. Because the percentage is in weight and the pan is heavy, few less than one kg, it represents the 8% of all the sample.
Other kinds of not recyclable waste are 0,5% of putrescible, of both kitchen paper and food waste, and 0,5 % of hazardous waste, present only as drugs.
Big are the quantities of recyclable fractions. In fact the 37,7% of the test is made of cellulosic materials, principally paperboard and newspaper and magazines. The 22,9% is made of glass materials and the 21% of plastics. Of this fraction the biggest measure is of bottles and containers, respectively for the 49,2% and 33,8% of the plastic sample, and the remaining part is other kinds of plastic, polystyrene and taps of bottles.
As for the sample 1, also in this case the quantity of metals is small, being the 6% of all the test, and it is made of aluminium cans.

5.1.3 Total results and comparison between sample 1 and 2

As it happened for the merceological analysis, also in this case the samples 1 and 2 have been put together to understand which is the overall trend of the twenty families. The total weight of the two samples is 35 kg; all the data referred to the total analysis are scheduled in Table K.
The percentages of each fraction are given by the sum of the percentages of the factions of sample 1 and 2; they are showed in Figure 5.3.
The overall sample has an efficiency of the 93%, and the 7% of the error is given by the presence in the sample of residual, putrescible, hazardous and other waste.

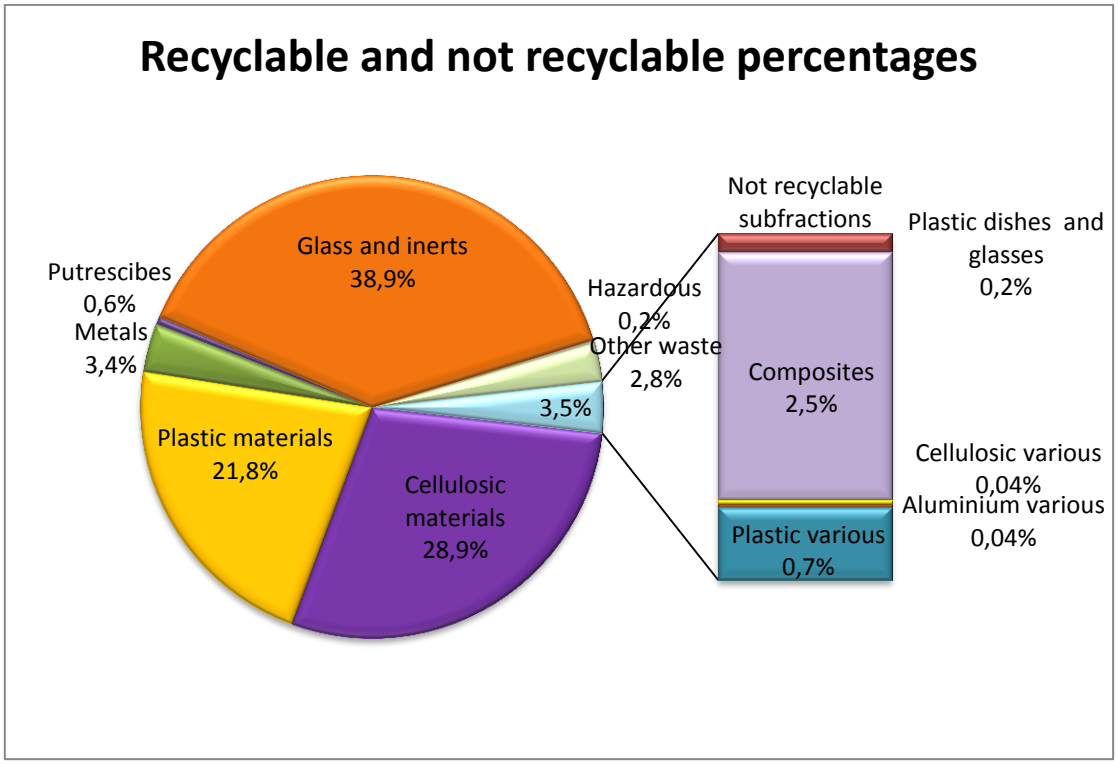


Figure 5.3. *Composition of the residual waste per each category of the sample 1 and 2 in December. The percentages are expressed on weight basis*

The residual fraction is largely composed of composites and part of plastic materials that are not recyclable; few amounts of cutlery, cellulosic and aluminium residual have also been found.

The other fractions that represent a mistake are 2,8% in weight of other waste (that is the pan found in the sample 2 test), 0,6% of putrescibles, of both kitchen waste and kitchen paper, and 0,2% of hazardous waste that are all drugs.

The 93% of the test is recyclable material. It is composed of glass, cellulosic, plastic and metals.

The 38,9% of the test is composed of glass, all bottles; cellulosic materials are also largely representative of the test, with the 28,9%, and how it happened for the sample 1 and 2, it is mainly made of paperboard and newspaper and magazines. The plastic materials are the 21,8% of all the test, and are composed of several subcategories: bottles and containers are the 80% of the category, and the remaining portion is made of various plastics, plastic films and bottles tops. The last 3,4% of the test is made of metals, all compose of aluminium cans.

Sample 1 and sample 2 had similar behaviour for the segregation of some fraction, and very different for others as Figure 5.4 shows.

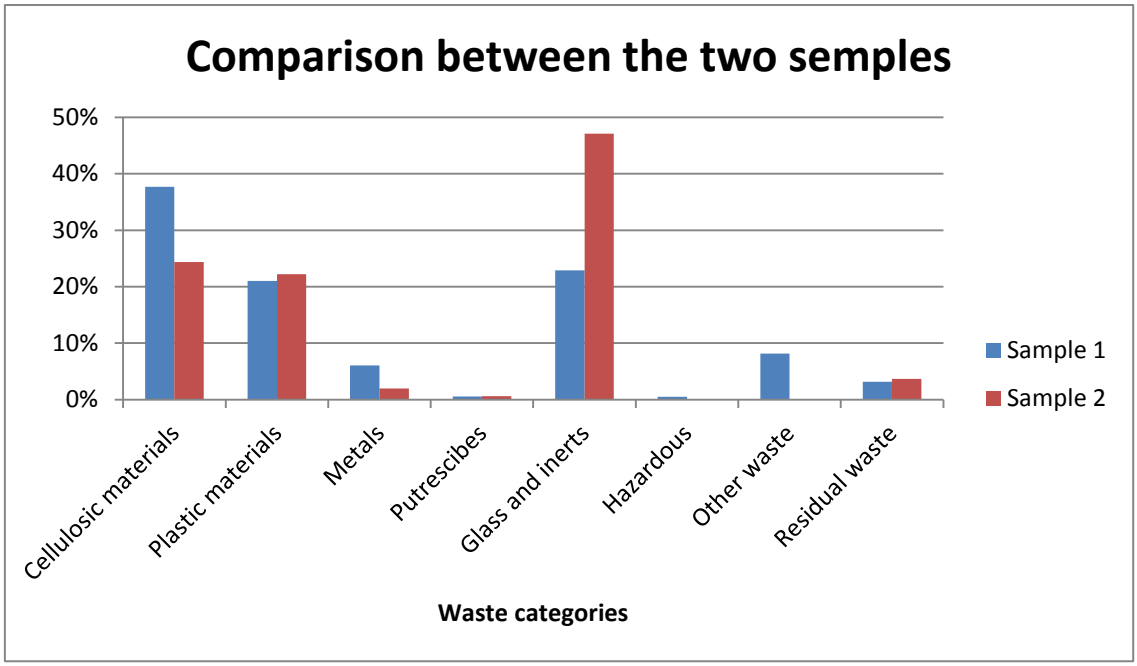


Figure 5.4. *Comparison of the recyclable fraction segregated between the sample 1 and 2. The percentages are expressed on weight basis*

Of the eight categories taken into account, very big is the difference in weight percentage of the cellulosic and glass production, with the difference that cellulosic material are more produced from sample 1 and glass from sample 2. This is the reason because, being at the seventh week the sample 1 composed from 42 people and the sample 2 from 12 people, there is not much difference in the weight of the waste; in fact sample 1 produced 23 kg and sample 2 produced 12 kg of recyclable waste and this little difference is given by the high amount of glass produced from the sample 2.

The plastic produced from the two samples is very similar and for both the cases its quantity is lower than the cellulosics and glass. Few trace of putrescible were found in both the case.

Traces of residual waste there were, but in few amounts for both the samples. This small quantity means that not big error is made in the recyclable waste segregated, and also that, differently than as expected, the sample 1 does not make errors in the segregation of the residual waste due to lack of knowledge.

5.2 Why to separate tops from plastic bottles?

During the analysis of the recyclable waste segregated from the two samples, the plastic bottles and the tops were considered separately.

This was done because some of the families, but also school and scout projects in the municipality collect separately the plastic tops to donate them to charity to assist the homeless, immigrants and mothers in difficulty. There are in fact in the region companies that buy the tops to recycle the plastic; the amount is the given to charity.

Separate the plastic tops from bottles is also useful to facilitate recycling. The two elements, in fact, are not recycled in the same way, since the materials from which they are made are different: PE for the caps and PET for bottles. Moreover following this way is also reduced the amount of waste, because the tops do not enter in the waste management of the municipality

In the analysis 140 grams of bottles tops were found, that means the 0,4% of all the weight. Of course it is not a big amount, but enlarging it to all the citizen it would at least facilitate the separation of some kind of plastic, in addition to the other aspects of charity.

5.3 Reusable fractions

Reuse is a means to prevent solid waste from going to the landfill, improve the communities, and increase the material, educational and occupational wellbeing of citizens by taking useful products discarded by those who no longer want them and providing them to those who do.

The definition of the term reuse is: using an object or material again, either for its original purpose or for a similar purpose, without significantly altering the physical form of the object or material.

The reuse of products requires fewer resources, less energy, and less labour, compared to recycling, disposal, or the manufacture of new products from virgin materials; moreover reuse prevents objects and materials from becoming waste. Therefore, reuse is considered to be a form of waste prevention as the Figure 5.5 shows.

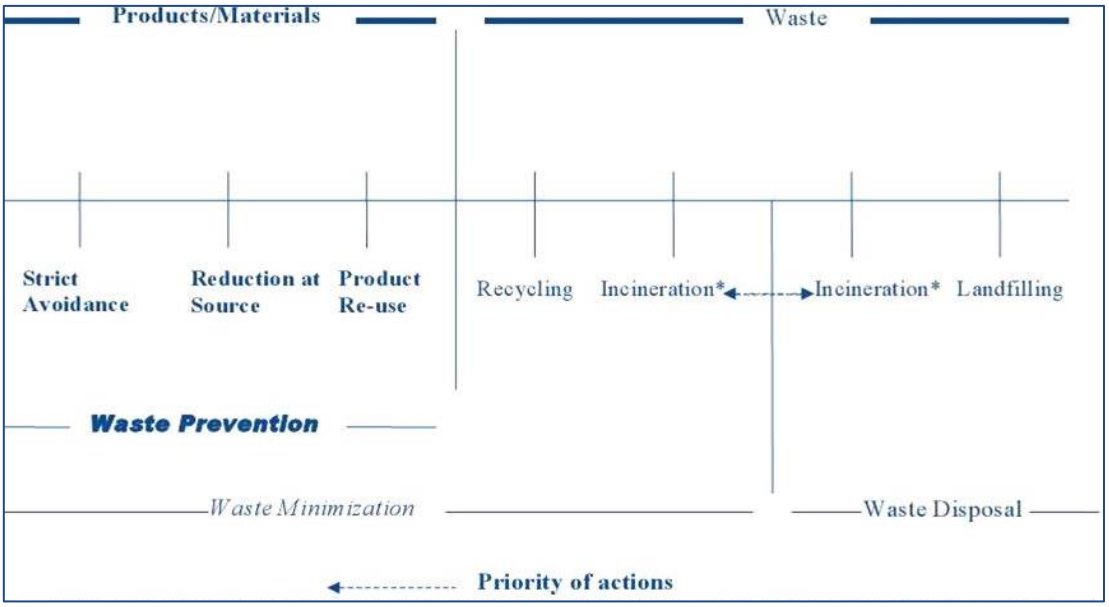


Figure 5.5. *Concept of prevention. Source: OECD 2000, OECD Working Party on Pollution Prevention and control, Strategic Waste Prevention*

Being the prevention the first action to do, it is fundamental to check if the citizen throw reusable material, and this was made during the two analysis of both the residual and recyclable waste.

During the first analysis of the residual waste, the reusable material was a woman bag, while during the second one the reusable material that were found are a door mat, a man belt and a coat hanger. All of this things were in good conditions, that had allowed other people their use; moreover, other reusable material that could be utilized again from the owner were plastic containers, for example for the detergent on tap, and plastic shoppers.

Through the analysis of the recyclable material, the reusable things that were found are a pan and several plastic containers. So of the huge amount of waste just a few part of it was reusable, this means that throwing away still good material is not a common habit.

In order to have an idea of what the families components think about the possibility to prevent the waste generation by the means of reuse, some questions were asked to them. All the families except two think that the reutilization of the materials is helpful for the waste managements, and most of them have bought second-hand; different are the answer about the sold of things they had used, in fact few of them did it, and someone answered that instead that buy, they gave directly things to other people without asking

anything back, and this does not happen just for small thing as clothes and accessories, but also bot bulky materials as sofas, furniture, and appliances.

Also if the 75% of the families bought second hand, just few of them know about the presence of second hand markets in the nearby.

Still in terms of waste prevention some family not only gives away things in a good state, but keeps thing they do not want any more for future necessity, as wood and paperboard to burn it in the fireplace.

Very interesting are the ideas of one component of one family, who is going to do a booth with glass bottles, made girl bags with old jeans and collected old fabrics of several things (as old t-shirt), has cut them into strips and sewed a carpet of numerous colours, as it possible to see in the figure below.

Figure 5.6. *Example of how to reuse old fabrics; realization of one family component of the sample.*

Chapter 6

Social and cultural approach on the local waste management

The concepts of sustainability and environmental respect as well in waste topics should be known and instructed to the citizen, also if they are not practised from the municipality; in fact they are concepts that people should put into practice for their own good and for that of future generations. Fundamental is then the role of schools that should teach students how better respect the place they live in.

6.1 What do schools do?

In a situation where the environmental problems look to increase day by day, there is the hope that at least the young citizen are educated in schools to the environmental respect; because of this some questions have been made to the deans of three schools of the municipality of Carini, and some questions have also been asked to the students, in order to see what they think and what they know about the waste segregation.

The schools were the tests have been made are two middle schools and one high school.

At thee middle school I.C.S. Laura Lanza the students follow an ecological course that treats environmental courses at 360° in collaboration with Legambiente which also makes activities of cleaning the environment; moreover some classes in turn must clean the exterior of the school picking up the dirt they left. Inside the classrooms are not present bins for the different fractions of waste, and outside plastic and paper are collected, but the segregation is not going on because of the lack of the collection system. The same is about the collection of special waste, in fact just the toner are collected and only the ones consumed by the school, so the student cannot use it collection point; time ago there was the batteries collection at school, but they have never been collected, so the service stopped.

The students, in collaboration with a private consortia, have been involved in the waste oils collection; a bin was delivered to each student, which at home could be filled with the oil, and then discharge the oil into one container situated in the town. Other actions are made from the school, as the Christmas tree made with plastic bottles, or the taps collection (§5.2), but this activities are not directly organized by the school, but from the teachers. To conclude the school does not use recycled or reused materials.

The situation does not change much at the middle school I.C.S Calderone where toner are collected just from the school, inside the classrooms are not present bins to differentiate the waste and recycled and reused materials are not utilized. Also here the students received the bins for the waste oil collection and they participate to environmental meeting and courses and projects. Differently than the other school, in this the collection of the paper works with a weekly collection.

Similar to the other two school is the situation at the high school IIS Mursia. In this school the students can participate to a course called “alternanza scuola lavoro”, that treats also topic of waste management. Differently than the other schools in this one there are containers for the collection of sanitary towels in the girls toilets; except this, only the collection of toners is made but also in this case it is valid just for the school and not for the students.

6.1.1 Test for the students

Some of the students participated to a test, exposed in Table L, to understand which are habits on waste segregation in their houses, and to know which are their knowledge on the same topic. The interviewed students were 213, mainly aged from 10 to 18, and just few of them were older than 18; 188 of them are resident in Carini, and the rest in near municipalities. The reason because it is important to understand if they are resident in Carini is that in this way is easy to make an estimation of the families in the municipality that make the segregation, in fact this is the only data that makes a difference about the residence.

Of the 188 students that are resident in Carini, just 33 make the source segregation of waste, that means just the 17% of them; while of the 25 students that are not resident in the municipality just 5 make the segregation.

In the municipality, the 33 families that make the segregation segregate plastic, paper humid and glass, and very few are the families that put attention on the segregation of batteries and drugs. Of all the students that do not make the segregation, the 71% of them would be interested on doing it, and the others do not know or do not want to do it. Of all the students, 171 would like to make the segregation at school especially for the fraction more utilized that are paper and plastic. This is also the answer to the question "Which other solutions would you like the school would make about the waste topic?" which had as most number of answer that they would like to start the segregation, followed by the request of more controls and sensitization, and utilize recycled materials; very few were the student who think that would not like any change.

Scholars think that several are the advantages that the separate collection could bring:

- Less resources taken from the environment;
- Cleaner environment and more respect of it;
- Less health risks;
- Less amount of waste;
- Less need of landfill.

As it was done for the families (§3.2.1) also at the students was made a test to know which are their knowledge on source segregation; the percentages of the answers are showed in Figure 6.1, and the answers in Table M.

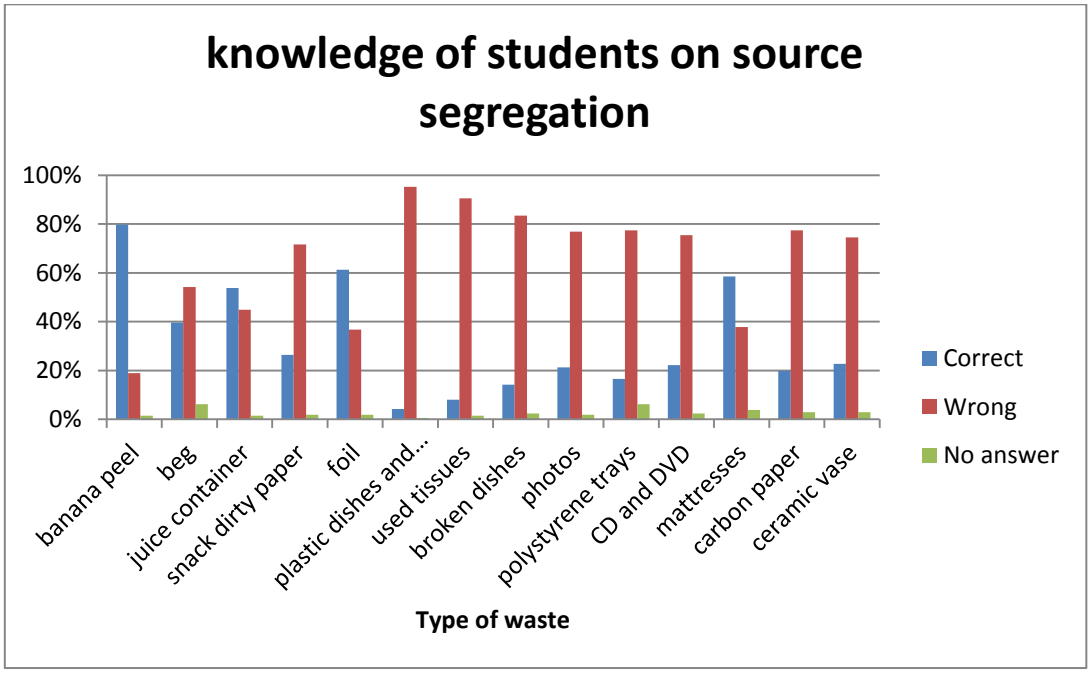


Figure 6.1. *Answers to test made at the students on the source segregation knowledge*

From the figure is easy to understand that the answers are all wrong except for banana peel, juice container, foil and mattresses, and the percentage of error is almost always higher than the 40%.

The knowledge of the students are then not good. This is the result of the fact that they not practice the segregation at home, and also the few instruction that is given them at school. The practical consequence of this could be an high error during the segregation once they will start to do it. Of course the students need to better understand how to differentiate the material, starting wondering what are composed of the things they want to get rid of; this may be done at school improving the environmental courses and making some practical example to better understand where they wrong.

6.2 What baby day-care do?

Disposable diapers are one of the most important product fractions in residual waste, in fact in Italy every day more than 6 million disposable diapers are used, making up more than 4% of all household waste; moreover for the production of diapers considerable amounts of chemical products (plastic, hydrogel, brighteners, etc.) are used, that then are disposed into the landfill. Because of this it is increasing, also from the public administrations, the interest in the washable nappies. This attention is also put in the municipal solid waste plan management of the Sicilia region, that dedicated a paragraph to the promotion at the washable nappies use.

It has also to be underlined that the use of the washable diapers is not a return to the past, but it is a most sensible attitude for the environment and also for the child, being they made of just natural material (cotton).

The interest given from the Sicilian region to the use of the washable nappies is not put into practice from the local administration in the municipality of Carini; in fact it would be expected that at least the public baby day care use them, but it is not like this.

In Carini there are two baby day care that have children from 0 to 2 years, one municipal and one private, and none of them known about the return of the washable diapers, and so they use the disposable nappies.

The municipal structure works five days per week, seven hours per day, and takes care of sixty children, 45 of which use the diapers. The children are changed two or three times during the working hours with the disposable diapers provided by the families; at

the end of the day the collected diapers in one big bag are thrown away into the containers, and so intended to the landfill. The nursery never took into consideration the possibility to use the washable diapers and would not also if the municipality would incentive to buy them, because in their opinion the families would not react well to the proposal.

The private daycare works with six children that use diapers, five days per week and 6 hours per day. Also in this structure disposable diapers are used, collecting a small beg per day, that at the end of the day is thrown away into the containers. Differently than the other structure, this one would start to use the washable nappies in case of the providing grants by the municipality to purchase, or if there was a reduction in the tax on waste.

In case both the structure would start to use the washable diapers, there would be a reduction of 8640 kg of residual waste per year; if this habit would be taken also from the families of the children at the nursery, the yearly overall reduction would be of more or less 44676 kg. This is already a huge amount of waste that could not be produced just changing the habits of the 51 families whose children go to the nursery, so taking into account that the children that have between 0 to 2 years in the municipality of Carini are 1322 (at the 30 November 2013), the overall saving could reach 1655 tons per year. Of course it is a very large estimation, because not all the families would make this change, but if what projected from the municipal solid waste plan management of the Sicilia region was put into practice by provision of grants for the purchase of washable diapers, creation of an information campaign even at hospitals and telephone advice to new mothers, this old/new culture could be encouraged and widespread reaching results near to the ones expected.

6.3 Detergents on tap

Detergents on tap are those detergents sold separately from bottles that have the same cleaning power. The bottle can be reused over and over again, so on the one hand the customer saves money and on the other the entire community save a lot because the costs of transportation, recycling and the environmental risks are reduced. The detergent bottles have in fact a great environmental impact; the purchase of conventional

detergents in plastic bottles means, besides the production of waste plastic, the production of a large amount of other waste as other packaging, and also the pollution caused by transport. By purchasing a bottle and then reuse that prevents this to happen.
This procedure is having a good result in the consumer choice, in fact not only it is extended to the sale of water by the reuse of the bottles, but also to the sale on tap, suitable for pasta, rice, biscuits, candies and so on.
The formula that makes this way of cost saving and environmental respect is possible is because it makes the consumer in a position to save cost and protect the environment by using less material through individual action. The benefit of this intervention is therefore the leading role of the consumer: its assumption of responsibility makes him immediately and then effectively actor and performer of this action. It is then also clear that having purchased a package that can be filled again, this facilitates the return of the customer at that point of sale, generating loyalty.
The significance of the detergent on tap is also present in the municipal solid waste plan management of the Sicilia region, which has the goal, between the others, to implement this practice by the information campaign on the benefits of this system and the installation of machines which collect glass bottles.
The importance of this methodology can be seen also from the analysis that has been made on the recyclable waste segregated from the 20 families; the 82% of the total plastic segregated is composed of bottles and containers, that represent also the 18% of the overall recyclable waste. If the practice of the detergents on tap as well as the water on tap would be followed, the quantity of waste that would not be produced is considerable.
In the municipality of Carini is present a big centre where are also sold pasta, rice, biscuits, candies, corns and vegetables on tap, and one shop which mainly sells detergents on tap. This second one sells 35 detergents for laundry and houses, for families but also professionals products for the companies. The amount of detergents sold to the citizen, without taking in account the companies, is about 200 kg per month, which means more or less 200 containers less every month in the waste. The number of consumers increases with the time mostly spreading the word, that is the best advertisement of the shop. It has to be said that probably just one of this shop in a municipality of more than 31000 is not enough, and better results could be obtained if more shops like this will open around the city.

Conclusions

The waste emergency in the Carini municipality is the result of a mismanagement where the waste are sporadically collected and any kind of separate collection is made; almost all of the citizen so do not make segregation, getting rid of all the waste together.
The major of the municipality said that things are going to change, in fact the next summer a new waste management is going to start with the introduction of the separate collection, which will see the citizen as first actors, having the duty of separating the different fractions of waste.
In order to have an idea of how would react the population at the source segregation, 20 families have been chosen, as most heterogeneous as possible, and it was asked them to make the fraction segregation, writing down the weight of the residual fraction weekly, and for the first and last week saving the same fraction because of the necessity to analyse it.
From the results of the merceological analysis of the first week result a very high efficiency in the residual fraction, that has a value of the 88,4%; the amount of recyclable materials in this fraction is pretty small, but dangerous is the presence of hazardous waste. Because of this high efficiency, in the last week it was analysed not only the residual waste, but also the recyclable fractions, since it was possible that by mistake part of the residual waste had been thrown there.
The residual waste collected during the seventh week had also an high efficiency on segregation, but as was predictable it decreased to 86,6%; in fact with the passing of the time, the citizen put less attention on the segregation, and becoming it a spontaneous action the error increases. What has to be taken into account is that also if the presence of hazardous waste is decreased, it is still present. From the analysis of the recyclable fractions results that, differently than how expected, they contain just a little part of not recyclable materials, that amounted to the 3,5% of all the waste.
A further consideration was made with the intention of understand how much would change the amount of waste disposed into the landfill if the only fraction to dispose would be the residual one. Considering the weights of residual waste that the families had written down during the seven weeks and adding to the mean value of procapita refuse waste produced yearly enlarged to all the citizen the weight of the napkins

utilized in the municipality in one year, it was determined that the amount of waste to dispose would be 18052 tons less every year than the actual one. This correspond to 10830924 of euros in less to devolve to the disposal and that could be utilized for better and more sustainable actions in terms of waste; but probably the fact that all this money would not go to private individuals who own the landfill where the waste are sent is the reason because difficulty and slowly things will change.

Appendix

- Table A: calculations of the initial knowledge test
- Table B: questions list delivered to the 20 families
- Table C: results of the first merceological analysis for the sample 1
- Table D: results of the first merceological analysis for the sample 2
- Table E: results of the first merceological analysis for the sample 1 and 2
- Table F: results of the second merceological analysis for the sample 1
- Table G: results of the second merceological analysis for the sample 2
- Table H: results of the second merceological analysis for the sample 1 and 2
- Table I: results of the analysis of recyclable waste for the sample 1
- Table J: results of the analysis of recyclable waste for the sample 2
- Table k: results of the analysis of recyclable waste for the samples 1 and 2
- Table L: Questions and test for the students
- Table M: answers on the knowledge test made at the students on the source segregation

Table A: calculations of the initial knowledge test

	PM	**C**	**R**	**U**	**G**	**O**	Right	%	Wrong	%
Lighters	6		21			3	21	70,0	9	30,0
Photos		3	25			2	25	83,3	5	16,7
Shells of mussels / clams / snails			23	6		1	23	76,7	7	23,3
Tea and infusions bags		3	6	21			21	70,0	9	30,0
Batteries for electronic devices	1		1			28	28	93,3	2	6,7
Flowers and foliage			6	22		2	22	73,3	8	26,7
Cigarette butts		1	26	2		1	26	86,7	4	13,3
Tetra Pak cartons (milk, juices, sauces ...)	1	11	15			3	11	36,7	19	63,3
Bedding for pets			24	2		4	24	80,0	6	20,0
Receipts		12	17			1	17	56,7	13	43,3
Wood from pruning			5	10		15	15	50,0	15	50,0
Hair			20	4		6	20	66,7	10	33,3
Vacuum cleaner bags filled			30				30	100,0	0	0,0
Dirty tissues		4	11	15			15	50,0	15	50,0
Disposable plastic cutlery	10		20				20	66,7	10	33,3
Plastic/polystyrene trays for food	16		14				16	53,3	14	46,7
Ceramic vases and jars			21		2	7	21	70,0	9	30,0
Fish bones			4	25		1	25	83,3	5	16,7
CD/DVD	3		24		1	2	24	80,0	6	20,0
Mattresses and furniture			3			27	27	90,0	3	10,0
Candles	1		20	1		8	20	66,7	10	33,3

PM = Plastic and metals	C = Cellulosic	R = Residual	U = Putrescible	G = Glass	O = Others

Table B: questions list delivered to the 20 families

Do you do source segregation? If not, why?	Do you think that a serious separate collection could solve the environmental problems of the place where you live?	Do you think that the waste emergency is due to a bad political leadership, to the incompetence of the companies dealing of the recovery/disposal or to a low diligence from the citizen?
Do you know what compost is? If yes, do you know how to produce it?	Do you produce home compost?	If the home compost production would make decrease the waste fee, would you be encouraged to produce it?
If a door to door collection of the putrescible fraction, to produce compost, would you separate this fraction? Would you buy the compost so produced?	Do you know if in area you live in, second hand market are present? If yes, have you ever been?	Have you ever bought second-hand? Have you ever sold something?
Do you think that the sale and the purchase of the second-hand could help the waste management?	Which do you think may be the actions that the public administrations should undertake to make a better waste management?	Do you think that the waste emergency also depends on socio-cultural factors? Which in your opinion are the possible solutions?

Table C: results of the first merceological analysis for the sample 1

	> 100 mm		> 75 mm		> 40 mm		> 20 mm		underscreen				tot category	
CATEGORIES	weight	%	weight	%	weight	%	weight	%	weight	%			weight	%
Cellulosic materials													1,648	17,6
Newspapers & magazines														
Paperboard			0,025	0,3	0,042	0,5								
Kitchen paper			0,004	0,04	0,067	0,7	0,051	0,5						
Textiles & Leather	0,404	4,3	0,11	1,2										
Wood	0,013	0,1												
Various			0,037	0,4	0,013	0,1								
Sorted cellulosic	0,829	8,9	0,053	0,6										
Plastic materials													2,728	29,3
Containers and bottles	0,134	1,4	0,034	0,4	0,037	0,4								
Shoppers			0,015	0,2										
Polystyrene														
Plastic films	0,014	0,2												
Dishes and glasses	1,227	13,2			0,585	6,3								
Various					0,007	0,1								
Sorted plastics	0,651	7,0	0,014	0,2	0,008	0,1	0,002	0,02						
Metals													0,499	5,4
Iron cans														
Aluminium cans					0,06	0,6								
Aluminium various	0,007	0,1	0,171	1,8			0,006	0,1	0,621	6,7				
Various metals														
Sorted metals	0,013	0,1	0,019	0,2	0,223	2,4								
Putrescibles													0,056	0,6
Kitchen waste					0,028	0,3	0,028	0,3						
Green waste														
Glass and inerts													0,416	4,5
Glass materials														
Ceramic materials	0,416	4,5												
Stones														
Sorted glass														
Hazardous													0,099	1,1
Batteries														
Drugs														
Others	0,063	0,7			0,023	0,2	0,013	0,1						
Composites													3,259	34,9
Sanitary napkins /diapers			0,257	2,8	0,378	4,1								
Tetra pack	0,192	2,1	0,017	0,2										
Others	0,836	9,0	0,243	2,6	0,657	7,0	0,679	7,3						
TOTAL residual	**4,376**	46,9	**0,696**	7,5	**1,851**	19,8	**0,681**	7,3	**0,621**	6,7	**8,225**	**88,2**		
TOTALE differentiable	**0,423**	4,5	**0,303**	3,2	**0,277**	3,0	**0,098**	1,1			**1,101**	**11,8**	**9,326**	100
TOTAL	**4,799**	51,5	**0,999**	10,7	**2,128**	22,8	**0,779**	8,4						

- Recyclable waste
- Residual waste
- % Residual waste

Table D: results of the first merceological analysis for the sample 2

	> 100 mm		> 75 mm		> 40 mm		> 20 mm		underscreen				tot category	
CATEGORIES	weight	%	weight	%	weight	%	weight	%	weight	%			weight	%
Cellulosic materials													0,53	17,6
Newspapers & magazines														
Paperboard					0,01	0,3								
Kitchen paper														
Textiles & Leather	0,312	10,4	0,138	4,6	0,045	1,5								
Wood														
Various							0,002	0,1						
Sorted cellulosic	0,023	0,8												
Plastic materials													1,073	35,6
Containers and bottles	0,067	2,2												
Shoppers	0,014	0,5	0,016	0,5										
Polystyrene														
Plastic films	0,11	3,6												
Dishes and glasses	0,483	16,0			0,019	0,6								
Various														
Sorted plastics	0,142	4,7	0,196	6,5	0,026	0,9								
Metals													0,006	0,2
Iron cans														
Aluminium cans														
Aluminium various					0,004	0,1	0,002	0,1	0,04	1,3				
Various metals														
Sorted metals														
Putrescibles													0	0
Kitchen waste														
Green waste														
Glass and inerts													0,04	1,3
Glass materials														
Ceramic materials					0,04	1,3								
Stones														
Sorted glass														
Hazardous													0	0
Batteries														
Drugs														
Others														
Composites													1,325	44,0
Sanitary napkins/diapers			0,021	0,7	0,103	3,4								
Tetra pack	0,097	3,2												
Others	0,741	24,6	0,127	4,2	0,134	4,4	0,102	3,4						
TOTAL residual	**1,701**	56,4	**0,482**	16,0	**0,367**	12,2	**0,102**	3,4	**0,04**	1,3	**2,692**	**89,3**		
TOTALE differentiable	**0,288**	9,6	**0,016**	0,5	**0,014**	0,5	**0,004**	0,1			**0,322**	**10,7**	**3,014**	100
TOTAL	**1,989**	66,0	**0,498**	16,5	**0,381**	12,6	**0,106**	3,5						

- Recyclable waste
- Residual waste
- % Residual waste

Table E: results of the first merceological analysis for the sample 1 and 2

	> 100 mm		> 75 mm		> 40 mm		> 20 mm		Undercreen				tot category	
CATEGORIES	weight	%	weight	%	weight	%	weight	%	weight	%			weight	%
Cellulosic materials													2,178	17,6
Newspapers & magazines														
Paperboard			0,025	0,2	0,052	0,4								
Kitchen paper			0,004	0,03	0,067	0,5	0,051	0,4						
Textiles & Leather	0,716	5,8	0,248	2,0	0,045	0,4								
Wood	0,013	0,1												
Various			0,037	0,3	0,013	0,1	0,002	0,02						
Sorted cellulosic	0,852	6,9	0,053	0,4										
Plastic materials													3,801	30,8
Containers and bottles	0,201	1,6	0,034	0,3	0,037	0,3								
Shoppers	0,014	0,1	0,031	0,3										
Polystyrene														
Plastic films	0,124	1,0	0,014	0,1										
Dishes and glasses	1,71	13,9			0,604	4,9								
Various					0,007	0,1								
Sorted plastics	0,793	6,4	0,196	1,6	0,034	0,3	0,002	0,02						
Metals													0,505	4,1
Iron cans														
Aluminium cans					0,06	0,5								
Aluminium various	0,007	0,1	0,171	1,4	0,004	0,03	0,008	0,1	0,661	5,36				
Various metals														
Sorted metals	0,013	0,1	0,019	0,2	0,223	1,8								
Putrescibles													0,056	0,5
Kitchen waste					0,028	0,2	0,028	0,2						
Green waste														
Glass and inerts													0,456	3,7
Glass materials														
Ceramic materials	0,416	3,4			0,04	0,3								
Stones														
Sorted glass														
Hazardous													0,099	0,8
Batteries														
Drugs														
Others	0,063	0,5			0,023	0,2	0,013	0,1						
Composites													4,584	37,1
Sanitary napkins/diapers			0,278	2,3	0,481	3,9								
Tetra pack	0,289	2,3	0,017	0,1										
Others	1,577	12,8	0,37	3,0	0,791	6,4	0,781	6,3						
TOTAL residual	**6,077**	**49,2**	**1,178**	**9,5**	**2,218**	**18,0**	**0,783**	**6,3**	**0,661**	**5,4**	**10,917**	**88,4**		
TOTALE differentiable	**0,711**	**5,8**	**0,319**	**2,6**	**0,291**	**2,4**	**0,102**	**0,8**			**1,423**	**11,5**	**12,34**	**100**
TOTAL	**6,788**	**55,0**	**1,497**	**12,1**	**2,509**	**20,3**	**0,885**	**7,2**						

- Recyclable waste
- Residual waste
- % Residual waste

Table F: results of the second merceological analysis for the sample 1

	> 100 mm		> 75 mm		> 40 mm		> 20 mm		Undercreen				tot category	
CATEGORIES	weight	%	weight	%	weight	%	weight	%	weight	%			weight	%
Cellulosic materials													1,942	21,6
Newspapers & magazines														
Paperboard	0,281	3,1			0,141	1,6								
Kitchen paper														
Textiles & Leather	0,837	9,3	0,190	2,11	0,027	0,3								
Wood														
Various			0,010	0,11										
Sorted cellulosic	0,433	4,8	0,003	0,03	0,020	0,2								
Plastic materials													2,387	26,5
Containers and bottles	0,336	3,7	0,040	0,44										
Shoppers	0,008	0,1												
Polystyrene	0,370	4,1												
Plastic films			0,012	0,13	0,021	0,2								
Dishes and glasses	0,520	5,8			0,407	4,5								
Various	0,161	1,8			0,016	0,2	0,004	0,04						
Sorted plastics	0,460	5,1	0,017	0,19	0,015	0,2								
Metals													0,09	1,0
Iron cans														
Aluminium cans			0,041	0,46	0,009	0,1								
Aluminium various									0,324	3,6				
Various metals														
Sorted metals					0,034	0,4	0,006	0,07						
Putrescibles													0,056	0,6
Kitchen waste					0,023	0,3	0,032	0,36						
Green waste							0,001	0,01						
Glass and inerts													0,514	5,7
Glass materials														
Ceramic materials	0,496	5,5			0,018	0,2								
Stones														
Sorted glass														
Hazardous													0,151	1,7
Batteries														
Drugs					0,007	0,1								
Others					0,144	1,6								
Composites													3,534	39,3
Sanitary napkins/diapers			0,100	1,11	0,356	4,0	0,046	0,51						
Tetra pack	0,130	1,4												
Others	1,264	14,0	0,481	5,35	0,973	10,8	0,184	2,04						
TOTAL residual	**4,38**	48,7	**0,803**	8,92	**1,871**	20,8	**0,236**	2,62	**0,324**	3,6	**7,614**	**84,6**		
TOTALE differentiable	**0,916**	10,2	**0,091**	1,01	**0,34**	3,8	**0,037**	0,41			**1,384**	**15,4**	**9,0**	100
TOTAL	**5,296**	58,9	**0,894**	9,94	**2,211**	24,6	**0,273**	3,03						

- Recyclable waste
- Residual waste
- % Residual waste

Table G: results of the second merceological analysis for the sample 2

	> 100 mm		> 75 mm		> 40 mm		> 20 mm		Undercreen				tot category	
CATEGORIES	weight	%	weight	%	weight	%	weight	%	weight	%			weight	%
Cellulosic materials													0,626	22,9
Newspapers & magazines	0,014	0,51												
Paperboard	0,017	0,62			0,002	0,1								
Kitchen paper					0,019	0,7								
Textiles & Leather	0,164	6,01			0,028	1,0								
Wood														
Various			0,072	2,6										
Sorted cellulosic	0,125	4,58	0,065	2,4	0,109	4,0	0,011	0,4						
Plastic materials													0,851	31,2
Containers and bottles	0,055	2,02			0,006	0,2								
Shoppers														
Polystyrene														
Plastic films			0,013	0,5										
Dishes and glasses	0,576	21,1			0,014	0,5								
Various	0,009	0,33												
Sorted plastics	0,132	4,84	0,046	1,7										
Metals													0,089	3,3
Iron cans														
Aluminium cans														
Aluminium various									0,067	2,5				
Various metals														
Sorted metals	0,069	2,53			0,020	0,7								
Putrescibes													0	0
Kitchen waste														
Green waste														
Glass and inerts													0	0
Glass materials														
Ceramic materials														
Stones														
Sorted glass														
Hazardous													0	0
Batteries														
Drugs														
Others														
Composites													1,096	40,2
Sanitary napkins/diapers							0,004	0,1						
Tetra pack														
Others	0,736	27			0,039	1,4	0,317	11,6						
TOTAL residual	**1,802**	66,0	**0,124**	4,5	**0,21**	7,7	**0,332**	12,2	**0,067**	2,5	**2,535**	**92,9**		
TOTALE differentiable	**0,095**	3,5	**0,072**	2,6	**0,027**	1,0	**0**	0,0			**0,194**	**7,1**	**2,729**	100
TOTAL	**1,897**	69,5	**0,196**	7,2	**0,237**	8,7	**0,332**	12,2						

- Recyclable waste
- Residual waste
- % Residual waste

Table H: results of the second merceological analysis for the sample 1 and 2

	> 100 mm		> 75 mm		> 40 mm		> 20 mm		Undercreen				tot category	
CATEGORIES	weight	%	weight	%	weight	%	weight	%	weight	%			weight	%
Cellulosic materials													2,568	21,9
Newspapers & magazines	0,014	0,1												
Paperboard	0,298	2,5			0,143	1,2								
Kitchen paper					0,019	0,2								
Textiles & Leather	1,001	8,5	0,19	1,6	0,055	0,5								
Wood														
Various			0,082	0,7										
Sorted cellulosic	0,558	4,8	0,068	0,6	0,129	1,1	0,011	0,1						
Plastic materials													3,238	27,6
Containers and bottles	0,391	3,3	0,04	0,3	0,006	0,1								
Shoppers	0,008	0,1												
Polystyrene	0,37	3,2												
Plastic films			0,025	0,2	0,021	0,2								
Dishes and glasses	1,096	9,3			0,421	3,6								
Various	0,17	1,4			0,016	0,1	0,004	0,03						
Sorted plastics	0,592	5,0	0,063	0,5	0,015	0,1								
Metals													0,179	1,5
Iron cans														
Aluminium cans			0,041	0,3	0,009	0,1			0,391	3,33				
Aluminium various														
Various metals														
Sorted metals	0,069	0,6			0,054	0,5	0,006	0,1						
Putrescibles													0,056	0,5
Kitchen waste					0,023	0,2	0,032	0,3						
Green waste														
Glass and inerts													0,514	4,4
Glass materials														
Ceramic materials	0,496	4,2			0,018	0,2								
Stones														
Sorted glass														
Hazardous													0,151	1,3
Batteries														
Drugs					0,007	0,1								
Others					0,144	1,2								
Composites													4,63	39,5
Sanitary napkins/diapers			0,1	0,9	0,356	3	0,05	0,4						
Tetra pack	0,13	1,1												
Others	2	17,1	0,481	4,1	1,012	8,6	0,501	4,3						
TOTAL residual	6,182	52,7	0,927	7,9	2,081	18	0,568	4,8	**0,391**	**3,3**	**10,15**	**86,5**		
TOTALE differentiable	1,011	8,6	0,163	1,4	0,367	3,1	0,037	0,3			**1,578**	**13,5**	**11,727**	**100**
TOTAL	7,193	61,3	1,09	9,3	2,448	21	0,605	5,2						

- Recyclable waste
- Residual waste
- % Residual waste

Table I: results of the analysis of recyclable waste for the sample 1

CATEGORIES	weight	% in weight	% category	% in category
Cellulosic materials		23,6		
Newspapers & magazines	0,77	3,4		13,6
Paperboard	4,49	19,6		78,8
Kitchen paper	0,12	0,5		2,1
Textiles & Leather				
Tetra pack	0,31	1,4		5,5
Various				
Sorted cellulosic				
Plastic materials		22,2		
Bottles	2,84	12,4		55,9
Bottles tops	0,09	0,4		1,8
Containers	1,15	5,0		22,6
Shoppers				
Polystyrene	0,03	0,1		0,5
Plastic films				
Various	0,97	4,3		19,1
Sorted plastics				
Metals		2,0		
Iron cans				
Aluminium cans	0,45	2,0		100,0
Aluminium various				
Various metals				
Sorted metals				
Putrescibles			0,1	
Kitchen waste	0,01	0,1		100,0
Green waste				
Glass and inerts		47,1		
Glass materials	10,76	47,1		100,0
Ceramic materials				
Stones				
Sorted glass				
Hazardous		0,0		
Batteries				
Drugs				
Others				
Residual waste		5,1		
Sanitary napkins and diapers				
Plastic dishes and glasses	0,05	0,2		4,4
Composites	0,77	3,4		66,4
Other waste				
Aluminium various	0,01	0,1		1,1
Cellulosic various	0,01	0,1		1,1
Plastic various				
TOTAL recyclable	**21,87**	**95,7**		
TOTAL residual	**0,85**	**3,7**		
TOTAL humid	**0,14**	**0,6**		
TOTAL other waste	**0**	**0**		
TOTAL hazardous	**0**	**0**		
TOTAL	**22,86**			

- Recyclable waste
- Residual waste
- Humid waste
- Other waste
- Hazardous waste

Table J: results of the analysis of recyclable waste for the sample 2

CATEGORIES	weight	% in weight	% category	% in category
Cellulosic materials		38,0		
Newspapers & magazines	1,89	16,1		42,5
Paperboard	2,20	18,9		49,7
Kitchen paper	0,04	0,3		0,8
Textiles & Leather				
Wood				
Tetra pack	0,32	2,7		7,1
Sorted cellulosic				
Plastic materials		21,0		
Bottles	1,21	10,3		49,2
Bottles tops	0,05	0,4		2,0
Containers	0,83	7,1		33,8
Shoppers				
Polystyrene	0,09	0,8		3,6
Plastic films				
Various	0,28	2,4		11,4
Sorted plastics				
Metals		6,0		
Iron cans				
Aluminium cans	0,71	6,0		100
Aluminium various				
Various metals				
Sorted metals				
Putrescibles		0,2		
Kitchen waste	0,03	0,2		100
Green waste				
Glass and inerts		22,9		
Glass materials	2,68	22,9		100
Ceramic materials				
Stones				
Sorted glass				
Hazardous			0,5	
Batteries				
Drugs	0,06	0,5		100
Others				
Residual waste		11,3		
Sanitary napkins and diapers				
Plastic dishes and glasses	0,01	0,1		1,1
Composites	0,10	0,9		7,6
Other waste (pan)	0,95	8,2		72,1
Aluminium various				
Cellulosic various				
Plastic various	0,26	2,2		19,3
TOTAL recyclable	**10,24**	**88**		
TOTAL residual	**0,37**	**3**		
TOTAL humid	**0,06**	**0,5**		
TOTAL other waste	**0,95**	**8**		
TOTAL hazardous	**0,06**	**0,5**		
TOTAL	**11,68**			

- Recyclable waste
- Residual waste
- Humid waste
- Other waste
- Hazardous waste

Table k: results of the analysis of recyclable waste for the samples 1 and 2

CATEGORIES	weight	% in weight	% category	% in category
Cellulosic materials		29,3		
Newspapers & magazines	2,66	7,7		26,2
Paperboard	6,69	19,4		66,0
Kitchen paper	0,16	0,5		1,5
Textiles & Leather				
Wood				
Tetra pack	0,63	1,8		6,2
Sorted cellulosic				
Plastic materials		21,8		
Bottles	4,05	11,7		53,7
Bottles tops	0,14	0,4		1,8
Containers	1,98	5,7		26,3
Shoppers				
Polystyrene	0,12	0,3		1,5
Plastic films				
Various	1,25	3,6		16,6
Sorted plastics				
Metals		3,4		
Iron cans				
Aluminium cans	1,16	3,4		100,0
Aluminium various				
Various metals				
Sorted metals				
Putrescibles		0,1		
Kitchen waste	0,04	0,1		100,0
Green waste				
Glass and inerts			38,9	
Glass materials	13,44	38,9		100,0
Ceramic materials				
Stones				
Sorted glass				
Hazardous		0,2		
Batteries				
Drugs	0,06	0,2		100,0
Others				
Residual waste		6,3		
Sanitary napkins and diapers				
Plastic dishes and glasses	0,07	0,2		3,0
Composites	0,87	2,5		40,1
Other waste (pan)	0,95	2,8		43,9
Aluminium various	0,01	0,0		0,6
Cellulosic various	0,01	0,04		0,6
Plastic various	0,26	0,7		11,8
TOTAL recyclable	**32,11**	**93,0**		
TOTAL residual	**1,22**	**3,5**		
TOTAL humid	**0,20**	**0,6**		
TOTAL other waste	**0,95**	**2,8**		
TOTAL hazardous	**0,06**	**0,2**		
TOTAL	**34,54**			

- Recyclable waste
- Residual waste
- Humid waste
- Other waste
- Hazardous waste

Table L: questions and test for the students

Age	10-12 years	13-15 years	16-18 years	> 18 years
1) Are you resident in Carini?		YES	NO	
2) Do you do source segregation at home?		YES	NO	
3) if yes, which fraction do you segregate? If no, would you be interested in doing it? _____				
4) Would you like to do the segregation at school?		YES	NO	
5) Which other solutions would you like the school would make about the waste topic? _____				
6) Which are in your opinion the advantages of separate collection? _____ _____				
7) Do you know what compost is and how to produce it?		YES	NO	
8) If yes make a brief description of the compost production _____				

9) Imagine to have the possibility to choose between this bins

Metals	Plastic	Glass	Paper	Humid	Residual

where would you get rid of…

	Metals	Plastic	Glass	Paper	Humid	Residual	Other
banana peel							
beg							
juice container							
snack dirty paper							
foil							
plastic dishes and glasses							
used tissues							
broken dishes							
photos							
polystyrene trays							
CD and DVD							
mattresses							
carbon paper							
ceramic vase							

10) If you doubt, which bin would you choose? (imagine u can't check on internet)

Table M: answers on the knowledge test made at the students on the source segregation

9) Imagine to have the possibility to choose between this bins

Metals	Plastic	Glass	Paper	Humid	Residual

where would you get rid of…

	Metals	Plastic	Glass	Paper	Humid	Residual	Other	No answer
banana peel	0	0	0	0	169	25	15	3
beg	0	8	0	0	0	84	107	13
juice container	1	52	0	114	13	21	8	3
snack dirty paper	1	33	1	107	21	35	10	4
foil	130	12	2	36	1	18	9	4
plastic dishes and glasses	0	195	1	5	1	9	0	1
used tissues	0	1	0	144	17	38	9	3
broken dishes	2	8	127	1	0	30	39	5
photos	0	32	1	99	1	45	30	4
polystyrene trays	2	35	0	4	2	60	96	13
CD and DVD	47	40	5	0	1	47	67	5
mattresses	0	1	0	1	6	72	124	8
carbon paper	4	5	0	121	1	42	33	6
ceramic vase	8	2	62	0	1	48	85	6

10) If you doubt, which bin would you choose? (imagine u can't check on internet)

1	2	2	7	2	85	57	56

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