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Experiencing Urban Mining in an Italian Municipality towards a Circular Economy vision

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Abstract

Selective waste collection in Italy has undergone significant changes over the last decade, highlighting very different approaches from one region to another. Research results presented in this paper are underlying differences between geographical regions and use them as a model of good practices to improve the less optimized systems. In the last decade, the Trento City Council has established a goal – the optimization of selective municipal solid waste collection – that led to a very low amount of recyclable materials in the residual fraction. More than that, for the first time sanitary textiles have been considered as a separable fraction at the source; for a long time this type of waste was considered negligible. These actions were transformed in a recycling program coordinated together with local recycling companies. This paper deals with factors associated with waste recycling, like specific criteria (waste containers selections for door-to-door collection, public awareness and tariff) and solutions (door-to-door bins, warnings, criteria for historic centers). The tourist characteristics of Trento makes it an interesting model for similar towns that are facing with the problem of optimization criteria. This opportunity is discussed referring to a Romanian case.

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1. Introduction

Tens of years ago, world's urban population generated in average about $0.6 \text{ kg inh.}^{-1}\text{day}^{-1}$ of Municipal Solid Waste (MSW); today the MSW generation in urban areas has reached up to $1.2 \text{ kg inh.}^{-1}\text{day}^{-1}$. In the forthcoming future the per capita generation is expected to reach $1.4 \text{ kg inh.}^{-1}\text{day}^{-1}$ [1,2]. The quantitative and qualitative properties of the MSW stream are mainly influenced by demographic change, climate, socio-economic and industrial development, environmental policies, policy makers, and interests of the parties involved in the production and use processes [3-11]. In a long-term vision, the technological, economic and environmental efficiency of any waste management system must take into account three dimensions: sustainability, society and economy [12-17].

Today, the waste management trend towards a zero waste framework is gradually shifting from the linear economy to a circular one [17-21]. The structured “take-make-dispose” approach used as a model in the linear economy has reached its end, being replaced by a refining and advanced concept where the priorities lean on the primary use of renewable energy that reduces the environmental concerns, where all the materials should be exploited (reuse, recycle or recovery) in an infinite number of cycles [22,23]. Considering the above mention, the evaluation of waste management performance is also based on several performance indicators such as: source separate collection (that registers the highest achievements in terms of rate and quality of the collected recyclable materials by type of fraction in comparison with mechanical sorting), waste collection systems (types of containers, schedules for emptying frequency of the containers or waste fraction collected) which is correlated with the effective collection distance, collection time and fuel consumption, waste collection units/deposition of the waste, territory suitability, existence of a competitive and open waste market, overall labor effectiveness which is highly connected with waste management system state of the art, and costs [24-26]. The quantity and quality of the separated collected waste performance relays on its recycling rates in terms of second raw materials recovery but, also, can be substituted in a result of a Solid Recovered Fuel that can be used as raw fuel with energy recovery purpose [27,28].

Waste management in Italy has undergone many transformations in the last decades; one of the consequences is that selective collection (SC) in urban areas is different from one location to another. The overall recycling MSW rates, in 2012, (including material recycling, composting and anaerobic digestion) in the EU-28 countries reached out to 40% (496 kg per capita of MSW generated in 2012), while Italy reached to a 37% rate (529 kg per capita of MSW generated in 2012) [29]. Considering the last European Commission report (2015) on “Separate collection schemes in the 28 capitals of the EU”, the SC rate in Rome reaches out to 16%, being sixteen, five and four times higher in comparison with Zagreb, Bucharest, Sofia respectively and close to the EU-28 average by capital of 18.5% [30]. On the other hand, in Italy the efficiency of MSW selective collection reached 65% in some regions [31,32].

In this frame, waste management, and especially SC, are priorities for the Municipality of Trento administration. In the last years, a lot of money has been invested in environmental sustainability; particular attention was paid for developing a reliable waste collection system and selective collection mainstream in particular. Waste management reorganization started in 2006 as a pilot project; at that time, waste selective collection was 46.5%.

This paper presents specific aspects derived from the Trento community experience in this field and also points out new criteria and solutions. The work is completed by considerations regarding materials destinations and consequences of SC on the Residual Municipal Solid Waste (RMSW).

2. Material and methods

The strategy set in the town of Trento for SC optimization bases on the Italian regulation integrated with local decisions, specifically at provincial level.

The country has taken and transposed the necessary actions through legislations that along the way has suffered a series of modification and changes introduced by the country itself or by the European community. In this frame in the Province of Trento the first step towards an environmental friendly waste management was in 1982 by the introduction of the regulation L.P. 29/82 that prohibited the uncontrolled waste disposal imposing the sanitary landfill concept.

SC of the organic waste from the MSW was introduced in the province by middle of the '90s.

The first National Packaging Consortium (CONAI) was founded in 1994 for the recovery and recycling of packaging waste (paper, cardboard, glass, plastics and metals) from the Italian market. This initiative engaged the Italian waste management market by increasing the number consortium and moving the trend specialized on comingled packaging waste management companies on only one type of packaging waste fraction. To this concern, in the Province of Trento packaging has been collected with variable strategies.

On 26th of January 1987 the province of Trento issued the Decree of the President of the Province (TULP), on environmental protection from pollution, considering also (though article 63, established in 1997) the recycling and composting of waste and implementation of SC. In 1997, the legislative decree 22/97 (known as Ronchi Decree) has been introduced as a new strategy model for waste management. The decree was linked with other legislative measures, aimed to establish the waste to energy norms and emissions limit values resulted from this activity.

Trento region has also adopted the packaging recovery scheme, introduced in Europe by a German decree (Decree" Toepfer) in 1991. This decree focused on the possibility of transferring the possibility of recovery to a third party authorized and controlled by the autonomous regions, model that was revised through the Decree "Novelle" in 1998 (Packaging Ordinance II) and most recently amended by art. 1 and 2 of "Packaging Ordinance" dated April 2, 2008. The same province adopted the L.P. 5/1998, regarding the selective collection organization and development, ensuring the minimization of RMSW.

Presently, the EU legislative priorities of waste treatment plants also establishes through Directive 2008/98/EC, that for 2020 sets a 50% target for waste reuse and recycling of household and similar waste produced and 70% target for reuse, recycling and other material recovery of non-hazardous construction and demolition waste. By 2030, the reuse/recycling targets increase to 70% of MSW and 80% of packaging waste (90% for paper by 2025, 60% for plastics, 80% for wood, and 90% for ferrous metals, aluminium and glass). To all of these, further targets can be added: a maximum landfilling rate of 25% for recyclable material and 30% reduction of food waste generation by 2025.

Regarding the waste collection system in Trento, over the years, the SC in this area has been operated by road container collection changed to door-to-door system (kerbside collection) as can be seen form Figure 1.



Fig. 1 SC systems over the years: road containers (a) and kerbside collection bins (b)

Based on the results achieved in pilot areas, the City Council of Trento decided the gradual extension of the new system to all other 10 city districts, by posting the resolution 27.2.2008 n. 13. The last area involved in the project, in the year 2012, was the historic city center including the restricted traffic area, for which it was elaborated a particular approach considering its architectural and historical characteristics (for example the construction of underground islands of different types: underground bells and containers placed on retractable hydraulic platforms).

Additionally, seven centers for waste collection (CRM) were opened simultaneously, in such a way citizens could deliver for free all those wastes that are not transferable on the traditional containers (e.g. household appliances, furniture, twigs, batteries, cloths and other textiles etc.), the objective is to avoid the abandonment of waste in the environment and give new life to the recyclable materials.

The keystone of the new waste collection system was the involvement of the citizens and consumers. Between 2008 to 2012 over one hundred informational meetings were organized in all city districts for all social and economic categories of consumers and more than 250 information points were opened in the districts, but also information was provided at events, fairs, days of reuse were established, etc. The goal was to properly inform the citizens, stimulate the sharing of a project of great environmental value, motivate and raise awareness on the need to manage with responsibly their waste. An environmental awareness project was developed aiming especially children and teenagers, teachers and students were involved in order to explain in a proper manner and adequate understanding level, the meaning of the SC and the need for everyone to take part and be involved.

Particular care has been taken, also in the production of information materials in multiple languages (Italian, English, French, Arabic, Chinese, Russian, Spanish), and also the materials images, in order to reach foreigners residing in the municipal territory. A number of meetings were organized with cultural mediators and representatives in the territory of the individual ethnic groups (Chinese, Arabs, citizens from Eastern Europe etc.) to explain and actively involve them in the project administration.

Since 1st of January 2013 the Municipality of Trento adopted the new TARES rates, following the introduction in November 2011 the Law Decree 201 so-called "Save Italy". The transition to TARES rates obliges citizens and consumers to hand in personally the RMSW because the criteria is less payment rates for those who produces less RMSW. With the previous system, the rate was calculated based on square footage of the homes and the number of family members. Now, however, a part of the variable portion takes into account the amount of produced RMSW.

Another significant aspect was to stimulate citizens with door to door collection system, in order to reduce gradually the average amount of waste produced, to adopt new standards concerning waste management and sought, and encourage to purchase products with less packaging. It was also encouraged the adoption of home composting, by granting discounts waste bill rates for those who adopt this system.

The evolution of the system shows today the fact that pricing have a crucial role. To briefly explain the system of TARES bill rates, it should be noted that for the collection of RMSW a new green sack branded TARES has been introduced, that residents in buildings with more than four apartments must necessarily use for residual waste. Once consumed the initial allocation of green sack (calculated on the number of family members and which also corresponds to the minimum fee in the bill), each additional lot will be purchased at a cost of € 2.69 (cost related to 2013). The individual users are instead equipped with a container of 120 liters equipped with a transponder, which allows users to record every emptying thanks to an electronic detection device. For each additional emptying, to the initial bill the sum of € 10.76 is charged (cost related to 2013). It is obvious that such a system encourages citizens to reduce as much as possible the amount of residual waste, to differentiate more carefully the other fractions (mainly glass, paper, packaging and organic) and to adopt waste reduction actions, such as buying products with less packaging.

The new system, running for just over a year, has achieved high increases of SC as seen in the introduction, but at the same time, some problems in the practical application of the new type of tariffs are recorded. In particular, the main problems are recorded in large apartment buildings, where they are often abandoned waste and where the residue is not collected in the sacks TARES. The waste management regulation provides penalties up to € 108 for those not using the sacks TARES and even sanctions for those who use incorrectly containers and abandoned waste. Local police was actively involved by checking and tracing those responsible for dropouts, but surely there is more to do in the field of information and empowerment.

Another point of particular "sensitivity" to the waste management are healthcare textiles (diapers and sleepers). The City Council has supported those who are in a position to use such materials, allowing a free allocation of special bags for the provision of healthcare textiles (diapers and sleepers). Financial support is also granted to families with children under 30 months of age (20 euro annual in 2013) and to those who buy cloth diapers (50% of the cost up to a maximum of € 50 in 2013).

The Administration's commitment is also consistent in terms of the initiatives to reduce waste. Many actions were addressed within the administration, several of them are: project on reduction of paper use by computerization of technological processes, project on green procurement, project on recycling in all municipal structures, organization on "Days of reuse" and for citizens (creating eco-volunteers citizens group, encouragement of home composting, "ecofeste" project) with the aim of reducing the amount of waste produced [15]. A project of great importance in this sense is taking place with retail chains, aimed at reducing the waste in a manner shared in stores. The project,

conceived in 2008 by the City of Trento under the name "Light expenditure", in 2010 was extended by the Autonomous Province of Trento in the whole province with the "Project Ecoacquisti Trentino" and currently involves 140 stores. It is also an ongoing project "LIFE" named "NO.WA - No Waste" in collaboration with the Municipality of Reggio Emilia and other partners including COOP and Environment Northeast Italy, to export this experience even in that municipality and at the Great distribution of the Reggio Emilia area.

Although there is still a lot of work to do in order to solve the problems mentioned above, the most significant concerns are the steady increase over the years of sense of responsibility of the Trentino citizens, in addition to the continuous reduction in the amount of unsorted waste.

3. Results and discussions

Results obtained from the pilot project of Gardolo and Meano were extremely positive both in terms of satisfaction of the residents, the level of recycling percentage increased from 47% (before) to 67% (Gardolo) and 73% (Meano). More in general, in 1998 the percentage of SC reached 9.9%, in 2005 45.8% and in 2013 74.7% (rising to 81.1% in 2016) as it can be seen from Figure 2. The most significant leap was recorded, as it can be seen from the data listed above, in 2013, following the introduction of the new TARES rates. In Table 1 details are shown on the flows of selective collection materials. Organic, and cellulosic alone reached 54.7% of SC in 2016.

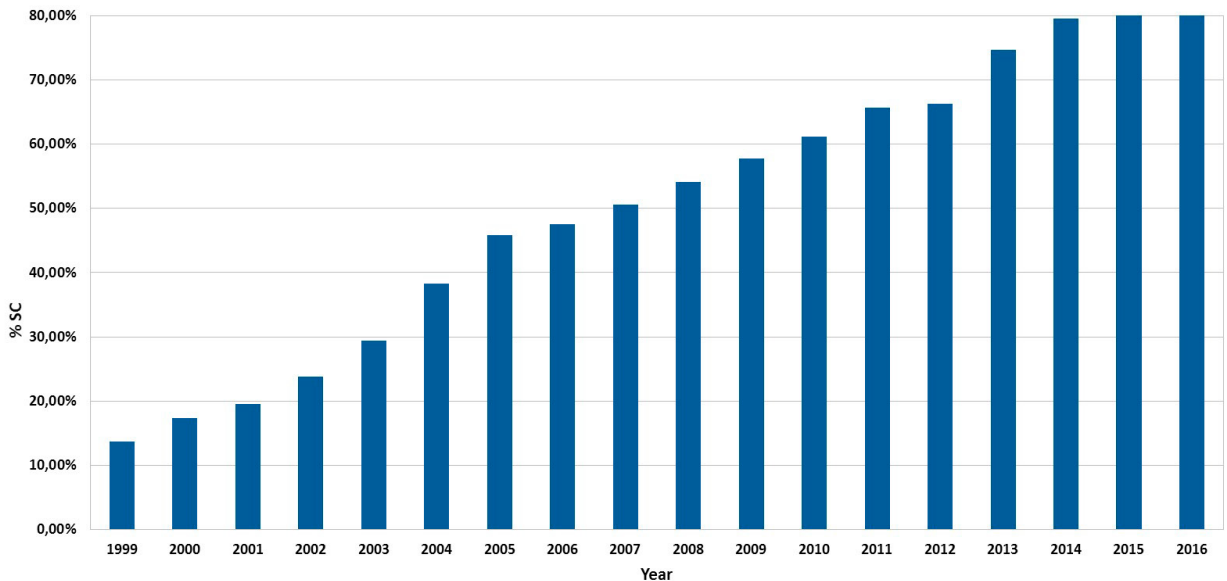


Fig. 2 Selective waste collection rates in Trento until the 70% target achievement (1998-2016)

The pathway starts way back in 2006 when a specific reorganization project started, and that allowed the achievement of 81.1% of waste selective collection in 2016. For its efforts and achievement, Trento city was considered the most honorable among other Italian provincial capital cities. This was possible because of intensive cooperation and common goals between Municipal Administration and the company in charge of the waste collection "Dolomiti Energia", but also the biggest role had all the Trentino citizens who shared the municipal administration project, who cooperate and did their best, day after day to manage as well as possible waste products.

The SC obviously needs to be coupled with an enhancement system for intermediary flows that has a high quality value. It is referred here the quality of the organic fraction which is significantly high. For such an enhancement is in the completion phase a plan for the construction of anaerobic digesters for the entire region.

As for the other flows, there was a critical point concerning light packaging. The difference is important because often for the citizens was not clear what is actually meant by packaging.

Table 1. Details on SC Trento Municipality in 2016 (data base: January - December)

FRACTION	TYPE OF SOURCE	
Organic	32.7%	Householders and industrial users
Green	6.8%	Public and private
Lightweight Packaging	10.7%	
Composite Materials	0.6%	
Glass Bottles	10.4%	
Paper And Cardboard	22.0%	
Metals	1.4%	
Plastics	0.8%	Not classified as light packages
Wood	5.3%	
Textiles	0.7%	
WEEE	1.9%	
Hazardous	0.3%	
Inert Materials	5.3%	
Other Types	1.1%	
OTHER TYPES OF MATERIALS SEPARATELY COLLECTED		
Bulky Waste	2.0%	compared to total municipal waste collection
Sweeping Waste	1.5%	compared to total municipal waste collection
EFFICIENCY		
SC efficiency	79.6%	
SC efficiency (no sweeping waste)	81.1%	

The composition of RMSW is reported in Table 2. The high medical textiles content gave the opportunity to set a specific aim: to perform and valorize this fraction. This aspect was discussed in the following years giving today the chance to the construction of a pilot plant for anaerobic digestion after pre-treatment.

It is obvious that the presence of only 4% of organic material in RMSW is influencing the entire energetic value of the waste (by increasing), and on its tractability (not biologically) as reported in the literature in recent years [2,5,12,22,33]. Waste management is in fact a complex integrated system in which the choices have consequences at environmental, economical and energy production level [34-41]. It should also be noted that the presence of high amount of medical textiles has led to deepen the possibility of a specific collection program aiming on recycling through separation of materials. In practice in extreme situations like the one of Trento, SC acts as a pre-treatment of municipal waste, as recently reported in the literature.

To summarize, in Figure 3 the evolution of MSW and RMSW in the last few years is presented. It is interesting to see declining trend of MSW generation even before the economic crisis. This trend could be related to a changed citizen behavior when buying. Another explanation could be that the reorganization of MSW collection avoids the inclusion of special waste in the stream of MSW.

A question can be put on the replicability of the experience of Trento. To this concern the Municipality of Sibiu, in the Transilvanian region of Romania seems to have the characteristics for it: number of inhabitants similar, cultural center, tourist town, mountain area, Austrian-like organization, local income higher than the national one. An opportunity for the transfer of the Trento expertise on SC is given by the collaboration between the University of Trento and the University of Sibiu in the sector of waste management. Maybe the most critical aspect that could delay the evolution of SC in Sibiu is the different impact of the tariff for waste management on the family income as the average salary is still significantly lower than the one in Trento.

Table 2. The composition of RMW in Trento 2013 after SC implementation, following the SC.

COMPOSITION OF RMSW	
Undersized	9.2% from which 54% less then 3 mm
Inert Materials	1.3%
Glass (Others)	0%
Other Ferrous And Non-Ferrous Metals	0.5%
Textiles	4.5%
Leather	0.8%
Other Plastics	4.2%
Rubber	4.9%
Medical Textiles	33.8%
Plastic Foils	14.2%
Polilaminates	0.4%
Others Not Classified	0.1%
WEEE	0.0%
Ferrous Metals	0.3%
Wood	1.3%
Glass (Bottles)	0.5%
Aluminium (Cans)	0.0%
Aluminium (Foil)	0.0%
PVC Plastics	0.2%
PET PE Plastics	1.8%
Paper	15.8% packaging, newspapers, journals, others
Cardboard	2.2% packaging, others
Degradable Organic	4.0%
Green Wood	0.0%
	100.0%

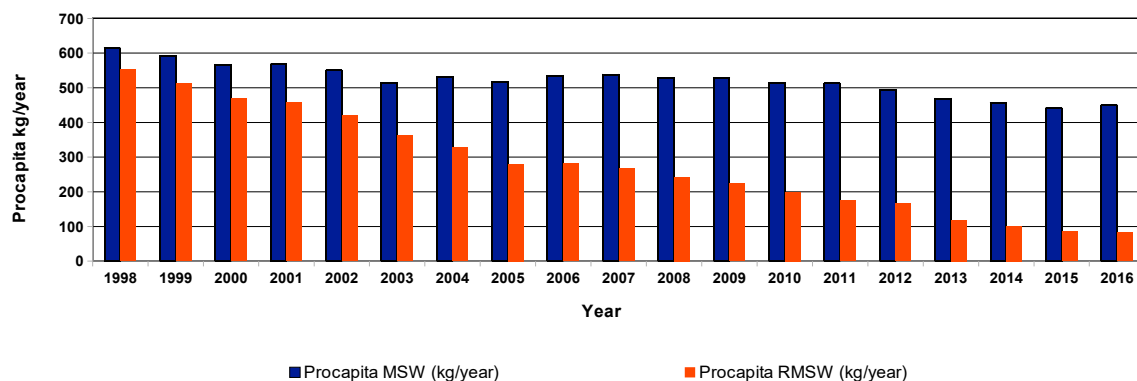


Fig. 3 Dynamics of per capita MSW and RMSW in Trento (year 1998-2016)

4. Conclusions

Trento community reached one of the highest level of waste selective collection and waste stream systematization in Italy, being as such a model for practical solutions and implementation systems for other cities. The present article on Trento is of particularly interest because of its dynamics and efficiency of selective collection systems. The study also presents practical results of waste selective collection efficiency and householders – public administration integration results. The Trento case study provides highest results of waste valorification and specific analysis of RMSW exploitation. Results cannot be obtained quickly: in 1998 the percentage of SC was 9.9%, raising to 81.1% in 2016. It can be concluded that the framing of eco-citizenship, legislation, municipalities, parties, and good coordinators of the afferent financial loop can lead to a reliable waste management schemes.

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