Plastic Waste Management: a comprehensive analysis of the current status to set up an after-use plastics strategy in Emilia Romagna Region (Italy)

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ABSTRACT

The evidence of the impact of the mismanagement of plastic goods in the environment has captured the attention of scientists, policy makers and manufacturers. Urgent measures, regarding a combination of preventing plastic use and massively improving waste management, have been acclaimed by different stakeholders with the common goal to make a more resilient and competitive plastic industry . European Commission has pledged itself publishing the first EU-wide policy framework on plastics. The new recycling targets and calculation method put under pressure the current waste management system (WMS), characterized by fragmentation in responsibilities and underperforming cost-benefit balance. In addition, the public-private governance and the increasing number in waste consortia and platforms contribute to make the waste streams traceability challenging. The following study, resulting from a collaboration between the University of Bologna (UNIBO), the Emilia Romagna Region (ERR) and the Regional Agency for Prevention, Environment and Energy (ARPAE), investigates the current panorama of plastic waste recycling system in ERR (Italy) with the aim to find out to what extent the current performance fulfils the future scenario established by the European Commission. The market of Secondary Plastics (SPs) has been investigated as well. The secondary resources, that are no longer waste, are not registered and monitored by official data collection scheme. Data extrapolated from official waste databases are integrated with results coming from individual questionnaire submitted to local recyclers. The identification of the main polymeric streams and therefore, the exploitation of economic potential represent the preliminary actions to strategically plan an after-use plastic economy whose main goal is having all recyclable and/or recycled plastic packaging by 2030.

KEYWORDS

Emilia Romagna region, plastic waste, secondary plastics, recycling, circular economy, waste management system.

INTRODUCTION

Plastics, and in particular plastic waste, are nowadays under the microscope of the whole world. The problem of marine plastic pollution has become so clear as to compromise the biodiversity but also the food chain and consequently, the animal welfare and the human healthcare (Thompson 2015). The evidence of the impact of the mismanagement of plastic goods in the environment has captured the attention of scientists, policy makers and manufacturers (Jambeck et al. 2015; Rochman 2016). The increasing production and consumption rates, the over packaging, the Chinese and Indian waste import ban, the lack of adequate infrastructure about waste management system (WMS) and the low consumer and producer awareness are some of the challenges to deal with (Paletta et al. 2019). Urgent measures, regarding to a combination of preventing plastic use and massively improving waste management performance have been acclaimed by different stakeholders with the common goal to make a more resilient and competitive plastic industry (Ellen Mac Arthur Foundation 2017). Plastics manufacturers and recyclers have responded through the engagement in partnerships, alliances and joint ventures (Foschi et al. 2018). European Commission has pledged itself publishing the first EU-wide policy framework on plastics (European Commission 2018a), reinforcing existing directive on waste and introducing specific policy on Single-Use-Plastics (SUPs). In fact, legal obligations about the management of municipal waste are laid down in the *Waste Framework Directive* (WFD), including 50% of household waste preparing for re-use/recycling target, to be achieved by 2020 (European Parliament and of the Council 2008). The Directive was recently revised by the *Circular economy package* to introduce more ambitious targets, including those for plastic packaging waste (PPW), based on reaching 55%, 60% and 65% recycling rates respectively by 2025, 2030 and 2035 (European Parliament and of the Council Directive 2018a; b). Additional purposes have also established within the *Strategy for Plastics in a circular economy*, where the Commission has set new ambitious goal by having 100% recyclable and/or reusable plastic packaging by 2030 (European Commission 2018b). Considering that the European recycling rate is estimated at 32,5% and the

market of Secondary Plastics (SPs) accounts for 8% in 2018 (PlasticsEurope 2019), targets seems really ambitious (European Commission 2018c). It is even more urgent in countries where the recycling rate is far below the European average (Dahlbo et al. 2018). European Member States (MSs), regions and cities are invited to incorporate driving forces in policy agenda to facilitate the achievement of targets in one side and strengthen the market of recycled plastics in another. The high amount of plastic waste generated every year provides a vast field of actions to shift the demand from virgin plastics - that today accounts for 51,2 Mt (PlasticsEurope 2019) to recycled ones. However, the current industrial recycling infrastructure is not up to the main challenge on plastics waste valorization. The increasing complexity in products design and the lack of transparency on the material composition struggle to guarantee a high quality of SPs (Pivnenko et al. 2016; Hahladakis et al. 2018a; b; Halden 2010). The monitoring of existing recycling performance supports the obstacles identification and the future scenario planning. This assumption is in line with the following study, resulting from a collaboration between University of Bologna (UNIBO), Emilia Romagna Region (ERR) and Regional Agency for Prevention, Environment and Energy (ARPAE). It investigates the current panorama of plastic waste recycling system in ERR (Italy) with the aim to find out to what extent the current performance fulfils the future scenario established by the European Commission. The analysis includes both waste and SPs in order to define the benchmark and detect the opportunities to strategically plan how to increment the amount of plastic waste to turn up into SPs. Finally, recommendations to deliver a well-functioning integrated and sustainable plastic WMS in accordance with the circular economy principles, have been proposed.

1. PLASTIC WASTE MANAGEMENT SYSTEM

Each EU MS has its own waste management system in accordance to the national law. In addition, waste is sorted and collected in different ways across the regions (Dahlbo 2018). The Italian WMS proves to be complex and heterogeneous. Municipal (waste from households and similar, also called post-consumer) and special (waste from industrial/commercial activities, also called pre-consumer) waste are managed in different ways: while special waste are handled by independent consortia or private companies, municipal waste are regulated by the national waste consortia. Municipal waste are generally packaging waste whose governance is characterized by a well-defined administration. In fact, packaging, including plastic packaging, are handled by official waste scheme as pushed by the statutory producer responsibility regime (OECD 2001; Hahladakis et al. 2018). Specifically speaking, municipalities entrust the waste management to Collective System or Consortia dealing with the cost coverage of post-consumer waste separate collection, sorting, recycling and eventually, disposal. As a result of the application of the Extended Producer Responsibility (EPR) principle - where producers and importers are responsible for the waste they generate and Sharing Responsibility - where stakeholders collaborate to pursue the waste hierarchy, the National Consortium for the Collection and Recycling of Plastic packages (COREPLA) runs the financial costs about the EoL of municipal PPW. In particular, the full costs generally include:

- Collection, transport and treatment costs for separately and non-separately collected waste
- Costs for public information and awareness raising
- Costs aimed to promote waste prevention actions
- Costs for litter prevention and management (Watkins et al. 2017)

In case of Italian governance, the COREPLA's financial structure is based on the overall cost for waste management minus the revenues coming from the sales of recovered material. In particular, municipalities entrust the waste management to COREPLA that is regulated by a specific national agreement stipulated (every five years) between ANCI (National Municipalities Association) and CONAI (National Packaging Consortium). Additionally, companies manufacturing plastics for packaging and packaging goods are forced to pay the so-called ANCI-CONAI contribution (CAC). As shown in the Figure 1 (Fig.1), CAC is a compulsory contribution which serves as a form of financing letting CONAI (and in this case, COREPLA) to support separate waste collection and packaging waste recycling operations (CONAI 2017). That system allows to allocate the responsibilities for the correct environmental management of packaging and packaging waste produced and used by more than 57 million citizens (CONAI 2017).

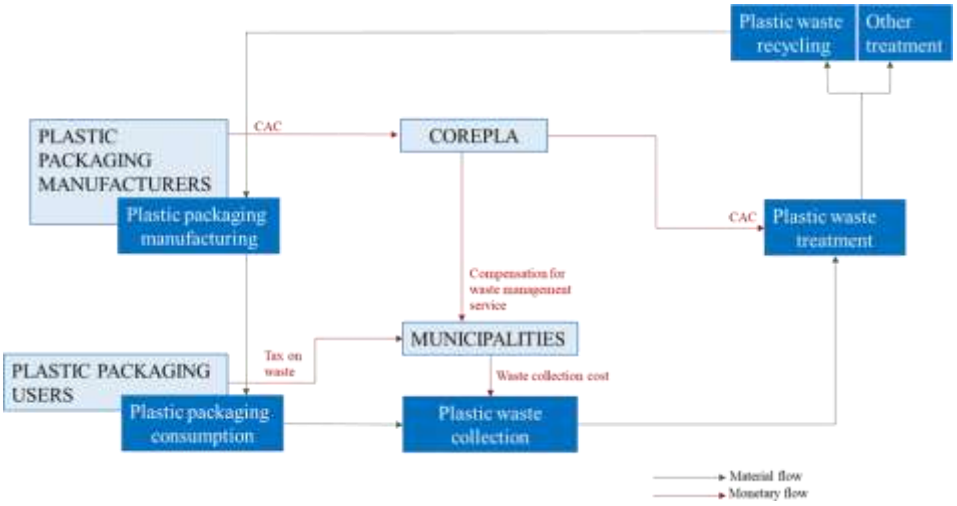

Fig. 1 – COREPLA's financial scheme

From the operational point of view, COREPLA basically manages the sorting of PPW for polymer (Polypropylene (PP), Low- and high-density Polyethylene (LD and HDPE), Polyethylene Terephthalate (PET)) and colour (transparent, white, coloured) and the sale of these stocks through electronic auctions to European recyclers (See Table 1).

Table 1 – Final products manged by COREPLA – Source: COREPLA

Product	Acronym (commercial name)
By-products[1]	**PLASMIX**
By-products	**PLASMIX_FINE**
By-products	**PLASMIX_FINE/F**
By-products	**PLASMIX/F**
Plastic boxes	**SELE-CAS/M**
Light blue PET bottles	**SELE-CTA/M**
NS	**SELE-CTC/F**
Coloured PET bottles	**SELE-CTC/M**
NS	**SELE-CTE/F**
HDPE rigid container	**SELE-CTE/M**
NS	**SELE-CTL/F**
Transparent PET bottles	**SELE-CTL/M**
Small/sized films	**SELE-FIL/S**
Film	**SELE-FILM**
PP packaging	**SELE-IPP/C**
NS	**SELE-MPET/C**
NS	**SELE-MPO/B**
Mix of PO packaging	**SELE-MPO/C**
Mix of PO packaging	**SELE-MPOF/C**

[1] By-products refer to the scraps generated during the treatment process in the waste plants associated to the consortium.

PO rigid containers	
NS	
PET containers	
NS[2]	

More specifically, COREPLA system is composed of:

- Centri Comprensoriali (CC) – *District Centers*: platforms where PPW waste are pre-treated
- Centri di Selezione e Smistamento (CSS) - *Sorting Centres*: platforms where PPW are basically treated and sorted

While municipal waste are generally heterogeneous and difficult to valorise, industrial waste are usually characterized by an homogeneous polymeric composition and therefore, an high market demand. In order to performe a positive cost-benefit balance, COREPLA plays an additional subsidiary role for industrial/commercial PPW by providing a framework of platforms to ensure the top-line profitability of packaging, such:

- PIA - *Platforms for general industrial packaging waste*
- PIFU - *Platforms for drums and tanks*
- PEPS - *Platform for Polystyrene (PS) based waste*

As described by the article 221 of the Consolidated Environmental Law, National Consortia can be combined with Independent Consortia where packaging producers and recyclers work to independently valorize their own plastic waste (Italian Government 2006; Ministero dell'Ambiente e della Tutela del Territorio e del Mare 2019).

As illustrated in the Figure 2 (Fig. 2), Italian plastic waste are managed by a multitude of National and Independent consortia and private companies.

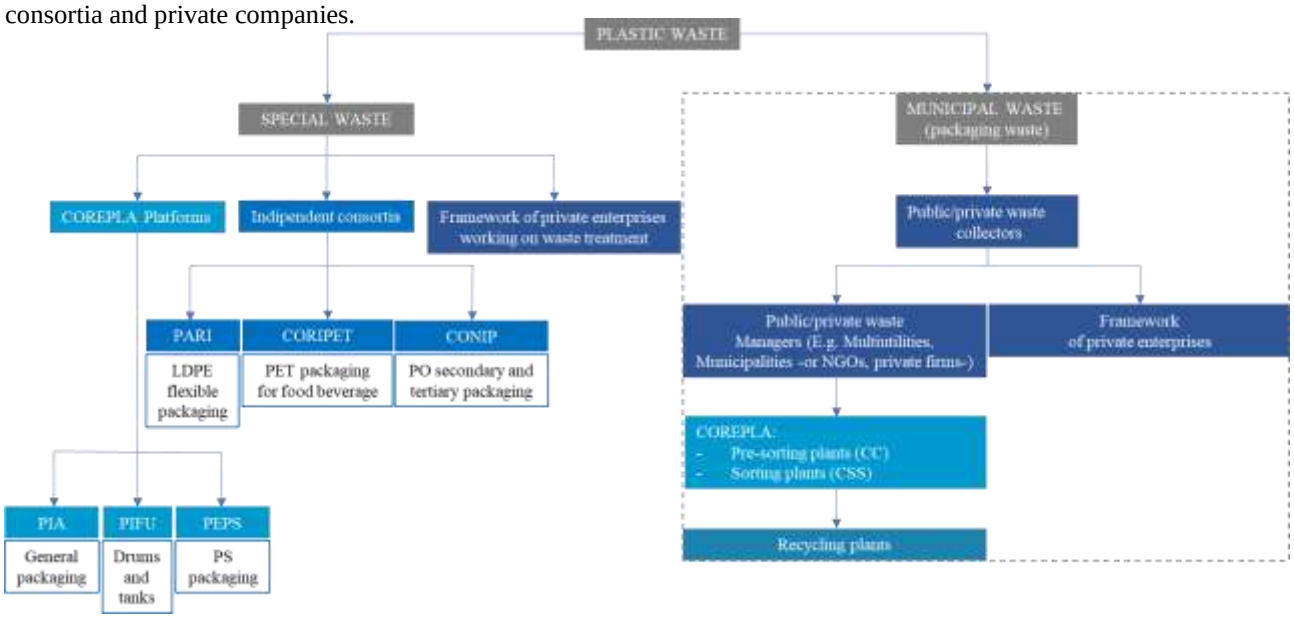

Fig. 2 – Plastic Waste Management System in Italy

While some Independent consortia are being validated, PARI, CONIP and CORIPET, respectively specialized in LDPE, Polyolefins (POs) and PET packaging recycling, are already operative in many locations in the country. As mapped in

[2] NS=Not specified. It includes experimental products.

the Figure 3 (Fig. 3), 8 companies working in PARI, 2 of 26 companies working in CONIP and 5 of 123 companies working with CORIPET are located in the region.

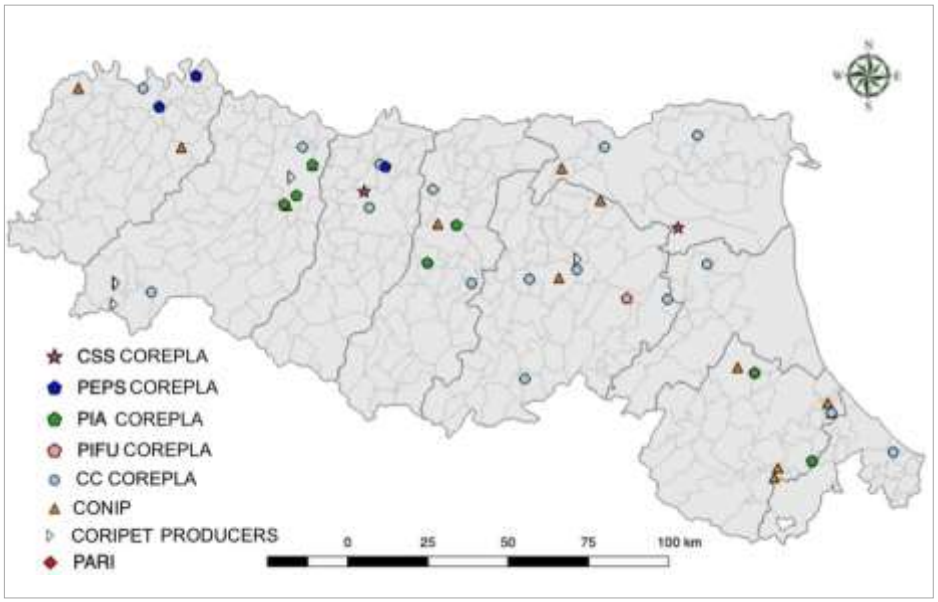

Fig. 3 – Location of plants (belonging to the plastic waste consortia) in Emilia Romagna Region

2. WASTE GENERATION AND MANAGEMENT

2.1 MATERIALS AND METHODS

The work investigates the management of both pre-consumer and post-consumer waste. Pre-consumer waste streams include waste coming from economic and industrial activities, such as agriculture and food processing industry, plastic, automotive and building and construction (B&C) sectors. Waste generated from waste treatment are also included in the investigation and considered with an additional relevance for the problem affecting the mix of plastics or more generally, the low-quality recyclables. The municipal waste considered within the study refers to the overall amount of post-consumer plastic packaging waste (PCPPW) collected through the integrated waste collection system implemented in the area. The assimilated waste, which are waste of a similar nature as household waste but collected from offices, schools, administrations, small businesses and communities, are monitored as well. The identification of the aforementioned waste streams has been performed in accordance with the categorization established within the European Waste Catalogue (See Table 2).

Table 2 - List of European Waste codes investigated within the study

EWC	Description
120105	Plastics shavings and turnings coming from shaping and physical and mechanical surface treatment of metals and plastics
020104	Plastics (except packaging) coming from agriculture, horticulture, aquaculture, forestry, hunting and fishing, food preparation and processing
150102	Plastic packaging (including separately collected municipal packaging waste)
160119	Plastics coming from end-of-life vehicles from different means of transport (including off-road machinery) and wastes from dismantling of end-of-life vehicles and vehicle maintenance (except 13, 14, 16 06 and 16 08)
170203	Plastics coming from construction and demolition wastes (including excavated soil from contaminated sites)

[3] Considering the overall number of CORIPET members, only few producers are located in the Region while all the recyclers are located outside the regional boundaries.

EWC	Description
191204	Plastics and rubber coming from wastes from the mechanical treatment of waste (for example sorting, crushing, compacting, pelletising) not otherwise specified
200139	Plastics coming from municipal wastes (household waste and similar commercial, industrial and institutional wastes) including separately collected fractions

141

142 The EoL monitoring includes all the steps, from the collection to the pre-treatment, sorting, recycling and remanufacturing
143 process. Both local and foreign disposal have been explored. As reported in the Table 3,the disposal options are
144 categorized according to the national Environmental Law.

1451 Table 3 – List of disposal options

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Code	Description of the disposal options
D1	Landfill
D2-D14	General disposal activities (Surface impoundment etc.)
D15	Temporary waste storage before D1-D14 processing
R1	Energy recovery
R2-R12	Material recovery
R13	Temporary waste storage before R1-R12 processing

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147 Data are sourced from ORSo (Osservatorio Rifiuti Sovraregionale) and MUD (Modello Unico di Dichiarazione
148 Ambientale) datasets that are generally used by waste managers and governmental organizations to monitor the EoL.
149 Since the analysis has been contextualized in the local infrastructure, the Material Recovery Facilities (MRFs) and
150 reprocessing plants have been firstly identified through PARIX, AIDA, AMADEUS and OSIRIS databases and then
151 geolocalized through the Geographic Information System (GIS). Finally, data about the SPs reprocessing capacity have
152 been provided with the intent to give a preliminary picture of closed-loop system. Considering that recyclers and
153 remanufacturers are reluctant to reveal their internal material flows and the market of recycled plastics, a questionnaire
154 has been submitted to local waste managers. The investigation includes data on ID, process and technology description,
155 input - output resources streams, their provenience and destination.

156 2.2 RESULTS

157 2.2.1 Plastic waste generation in Emilia Romagna Region

158 Emilia Romagna is one of the most proficient Italian regions, located in the Northern area with a territory of 22,123 square
159 kilometres and 4,5 million inhabitants. It comprises 331 municipalities and 6 provinces ((Ferrara, Forlì-Cesena, Modena,
160 Parma, Piacenza, Ravenna, Reggio Emilia and Rimini). The economic system is mainly feed by the manufacturing sector,
161 including 43.000 companies and 480.000 jobs (UNIONCAMERE 2019). The demographic and economic growth has
162 affected the waste generation and the need to rethink the entire system towards more circularity and sustainability.

163 2.2.1.1 Plastics in Municipal Solid Waste (MSW)

164 Whitin ERR, the amount of PCPPW disposed by separate collection scheme accounted for 47% (132.773t, corresponding
165 to 30kg per inhabitant) in 2017. The remains (53%) were registered into the residual waste stream where, about 35%
166 would be recoverable, if correctly separated (ARPAE 2018). The amount of assimilated waste accounted for 11.729t in
167 2017.

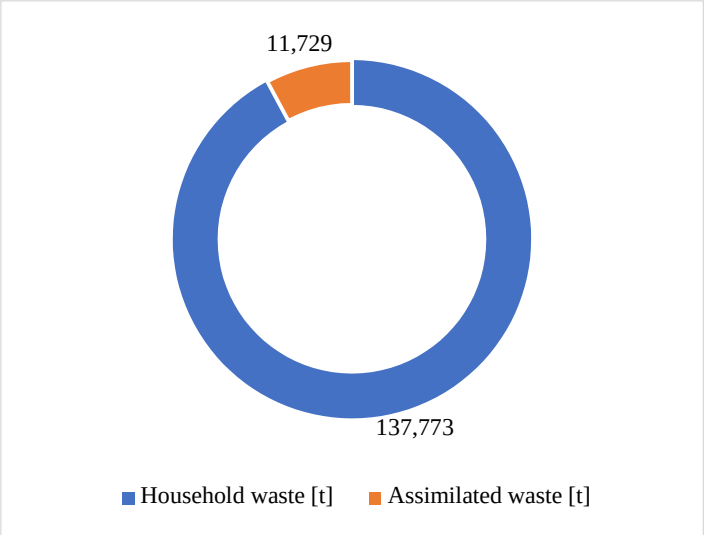


Fig. 4 - Separate Plastic Waste Collection, 2017

Figure 5 (Fig. 5) represents the Municipal PPW generation disposed by separate collection scheme in the region. 47% of regional Municipal PPW had been produced in three provinces: Bologna, Modena and Reggio Emilia.

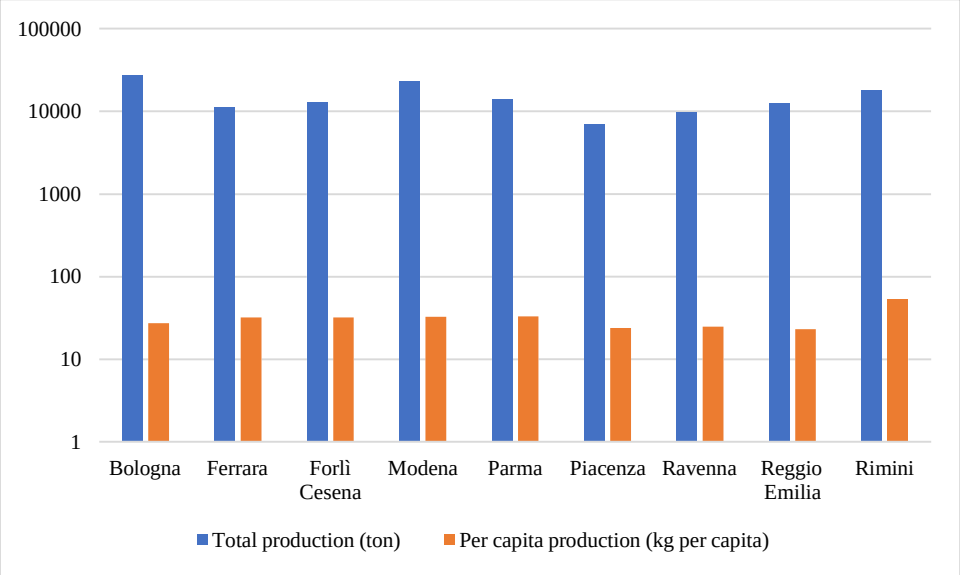
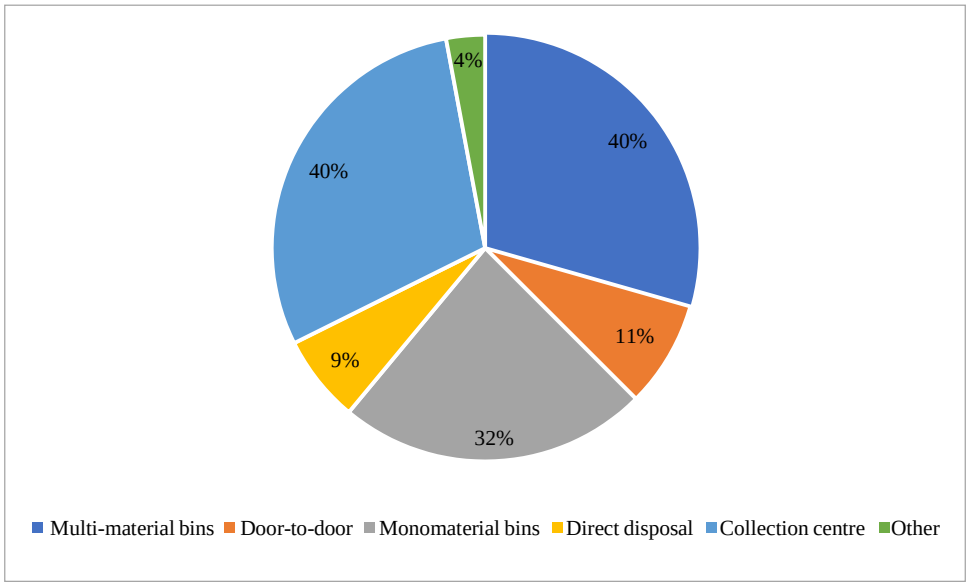


Fig. 5 – Municipal Plastic Packaging Waste generation, 2017 - Source: ORSo database

As for collection systems, 40% of the plastic was collected together with other waste in the multi-material collection. The most widespread system includes bring sites (that may be mono or multi-material) followed by door-to-door collection and collection centres. The assimilated waste are directly sent to disposal through one-to-one agreements (Fig.6).



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178 Fig. 6 – Municipal Plastic packaging waste collection, 2017 - Source: Regional waste report (ARPAE, 2018)

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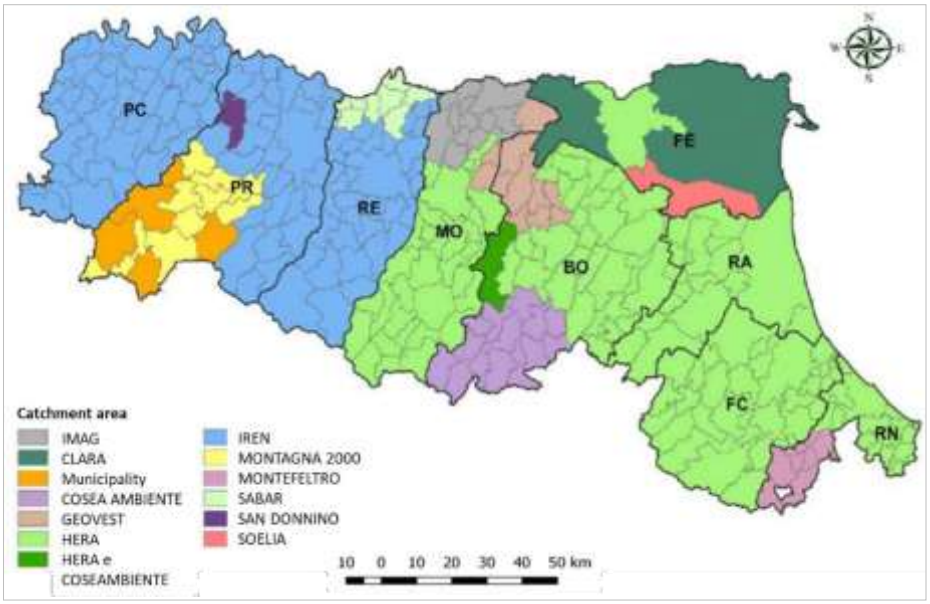
180 As mapped below (See Fig. 7), the collection service had been ensured by 11 multiutilities.



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182 Fig. 7 Catchment area served by the multiutilities working in the region – Source: ARPAE, 2018

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184 2.2.1.2 Plastics in Special Waste (SW)

185 Since the ERR is characterized by a profitable economy with more than 407 thousand companies, the generation of
186 industrial waste are considerably high. The overview of SW production is reported below according to the EWC and the
187 area of generation (See Fig.8).

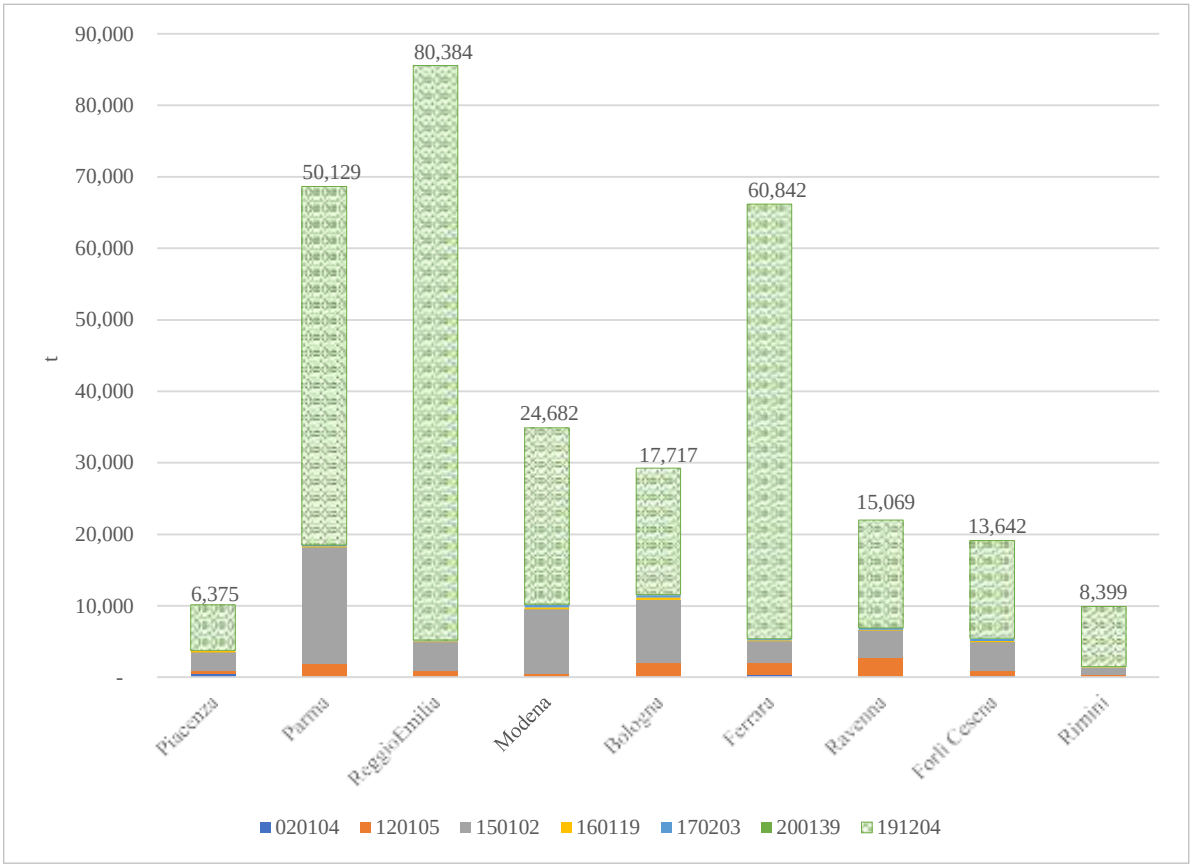


Fig. 8 – Special Plastic Waste generation, 2017 - Source: MUD database

Referring to primary generation of waste as waste coming from economic activities, a substantial stream is represented by waste classified by the 120105 EWC and generated by the plastic industry that is one of the most remunerative economy in the region. Plastics quantitative pulled out from End-of-Life vehicles (ELVs) was considerably high in 2017, accounting for 1.706 t. Agricultural plastic waste accounted for 1.297t and were mainly registered in the rural area, where the economy is basically based on farming. The presence of plastics in construction and demolition (C&D) waste is generally variable and influenced by a multitude of external factors (earthquakes and type of demolition, for example). The highest waste stream, codified by 191204 EWC (277.239 t), refers to scraps coming from the regional waste treatment plants and categorized in the secondary generation stream.

2.2.2 REGIONAL PLASTIC WASTE MANAGEMENT

The potential processing capacity differs from the collection rate for the amount of waste imported from other regions and/or countries. The overall amount of plastic waste managed in ERR was about 448.539 t in 2017, 27% of which came from regional activity and 73% from other regions and countries.

As shown in the pie chart below (Fig. 9), most of the waste (about 322.714 t) were processed through recycling and/or recovery operations (R2-R12). 58.270 t of waste were stored to be recycled/recovered later (R13). 62.261 t of waste were valorized to produce fuel or energy (R1). 2.464 t of plastic waste were sent to disposal activities (D2-D14) and 2.788 t had been treated before being sent to landfill sites (See Fig. 10).

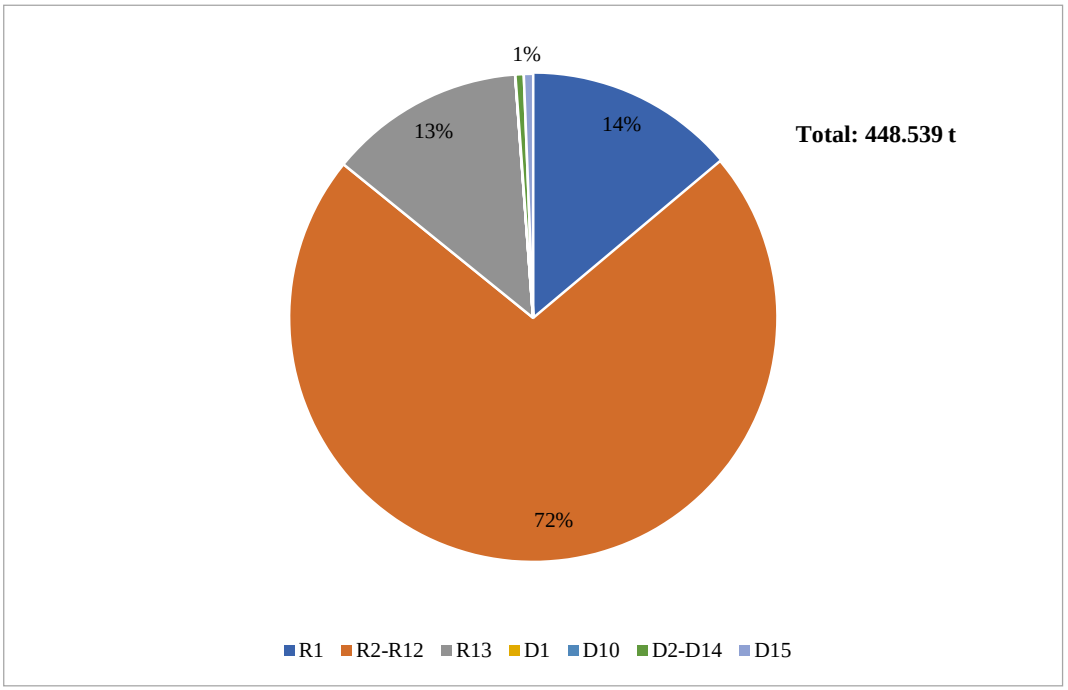


Fig. 9 - Plastic Waste treatment, 2017 - Source: MUD database

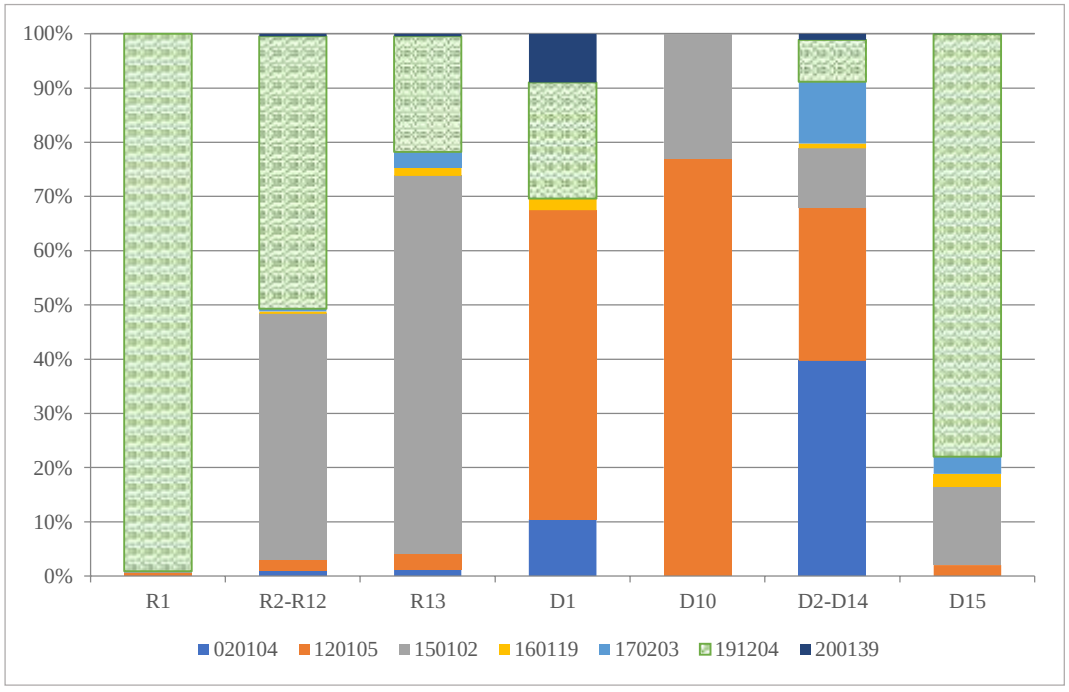


Fig. 10 - Plastic waste treatment, 2017. Analysis by EWC. - Source: MUD database

In 2017, about 190.436 t of regional plastic waste were exported. 67% of which was sent to national MRFs. As of national export, Lombardia and Veneto regions had received the largest amount of regional plastic waste, respectively accounting for 44% (56,527 t) and 31% (39,346 t) (See Fig. 11).

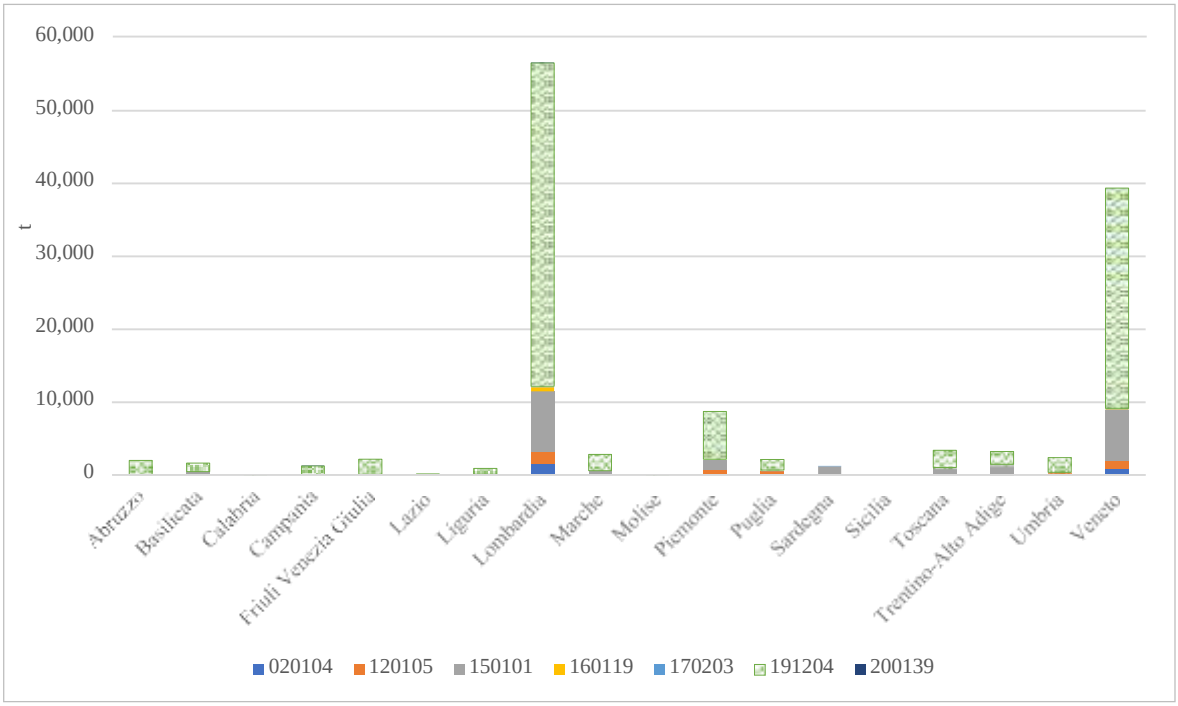


Fig. 11 - National export of regional plastic waste, 2017 – Source: MUD database

In the same year, 62.549 t of plastic waste were exported from Emilia-Romagna to foreign countries. As shown in Figure 12 (Fig. 12), Austria (33%, corresponding to 20.789 t, Germany (20%, corresponding to 12.409 t,) and China (14%, corresponding to 8.562 t) were the main destinations. The major circulating waste stream was represented by the scraps generated within the MRFs that, in case of plastics, is generally represented by the mixed and/or contaminated polymers.

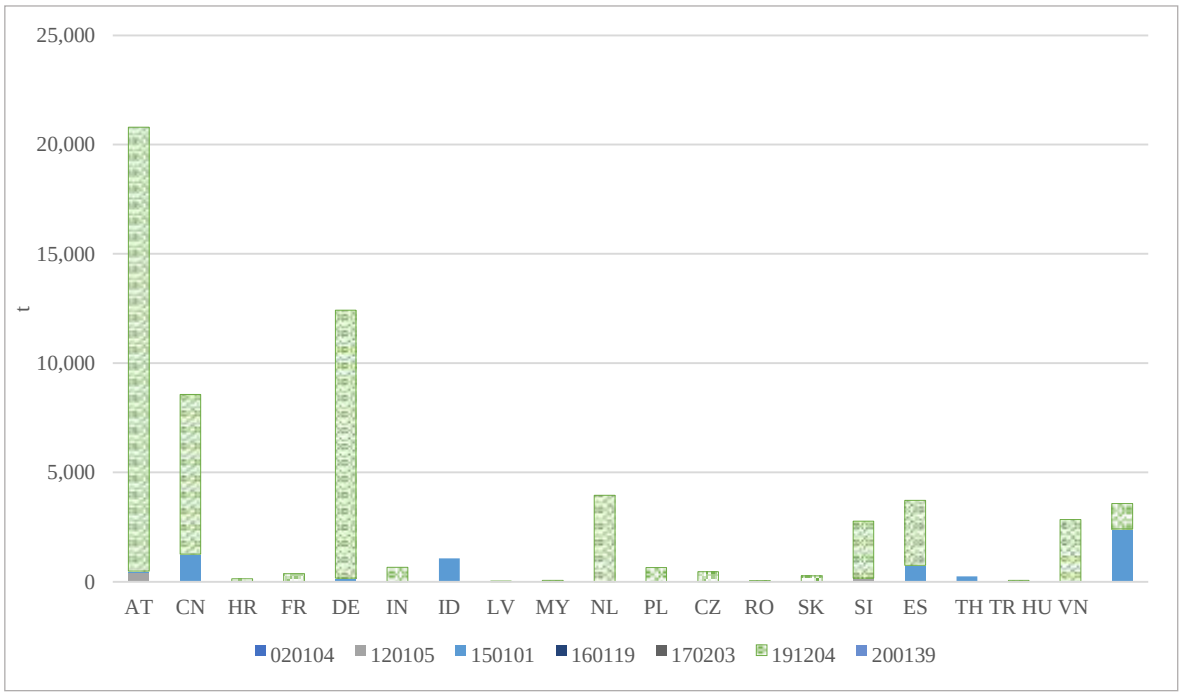


Fig. 12 – International export of regional plastic waste, 2017 – Source: MUD database

2.2.2.1 Municipal plastic waste management

As established by the article 182bis of the Legislative Decree 152/06, the regional self-sufficiency[4] of municipal waste management has pushed ERR to maximize the amount of waste to manage internally (Italian government 2006). This

[44] Every Italian region should be able to manage all the waste generated within its borders.

principle has catalysed the interaction between waste operators, consortia and enterprises working within the regional borders.

Regarding primary management, 76% of PCPPW stream was sent to recovery[5] in 2017 (ARPAE 2018). Public waste operators managed 91% of the overall amount of PCPPW separately collected in the Region (corresponding to 121,004t). In particular, 96,711 t of PCPPW (corresponding to 70%) were managed by COREPLA through a framework of pre-treatment (CSR) and sorting plants (CSS) (See Fig. 13).

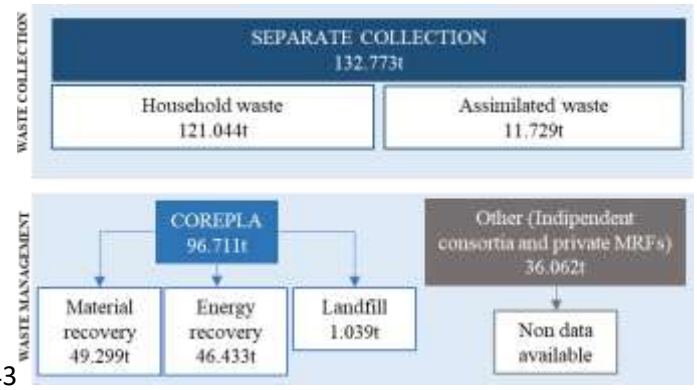
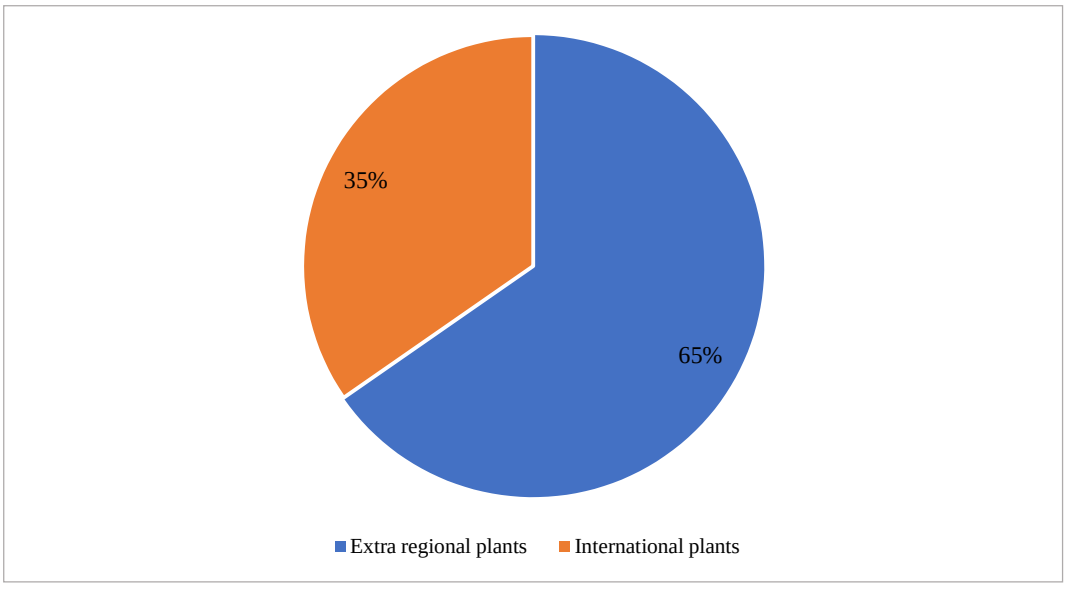


Fig. 13 – End of Life for Municipal plastic packaging waste in ERR, 2017

2.2.2.2 Industrial plastic waste management

Since industrial waste are characterized by uniformity in quality and quantity, each waste stream is handled by specific recycling market. In 2017, 25 regional companies treated 3.356t of waste coming from agricultural activities (EWC 020104), 10 plants of which performed a complete recycling process (R3). 38 regional plants managed plastic shavings coming from the manufacturing industry, 27 of which have recycled 5.512 t out of 6.205 t (90%). The complete recycling of 920 t (72%) of plastics coming from ELVs (EWC 160119) was performed by 15 plants. The regional plants handling waste classified by the EWC 160119 were 31 and managed 1.270 t of plastics. Other 9 plants treated plastic waste coming from C&D waste (EWC 170203) with a capacity of 713 t (41% of the total amount). A distinct consideration has been done for scraps generated by MRFs: when plastic waste are treated, they can change the waste codification by adopting the 191204 EWC. 29 of the 53 regional plants entitled to treat this kind of waste processed the 25% (39.932 t) of the total amount in 2017. It also represents the main waste stream exported outside the region. As shown in the Figure 14 (Fig. 14), 163.338 t of plastic industrial waste were exported in 2017.



[5] It includes both material and energy recovery.

Fig. 14 – Export of industrial plastic waste, 2017 – Source: MUD database

2.2.3 VALORIZATION OF PLASTIC WASTE INTO SECONDARY PLASTICS: A PRELIMINARY INVESTIGATION

The authors have run a survey to the regional plastic recyclers with the aim to provide a micro-scale analysis of the entire recycling chain. The survey has included 91 plastic waste remanufacturers. The number of respondent's accounts for 19%; however, 5 of them manage the largest amount of plastic waste in ERR. Even if the outcome is not representative of the entire regional market, the survey provides a preliminary overview of market needs and demands. As shown by the Figure 15 (Fig. 15), the regional infrastructure mainly works for sorting polymers by colours and types. Only 38% of the sample performs a complete remanufacturing process. The sorting performances are higher in case of LDPE, PP and PET as they are easily recyclable. However, a considerable amount of plastics is plasmix which represents an economic as well as environmental impact.

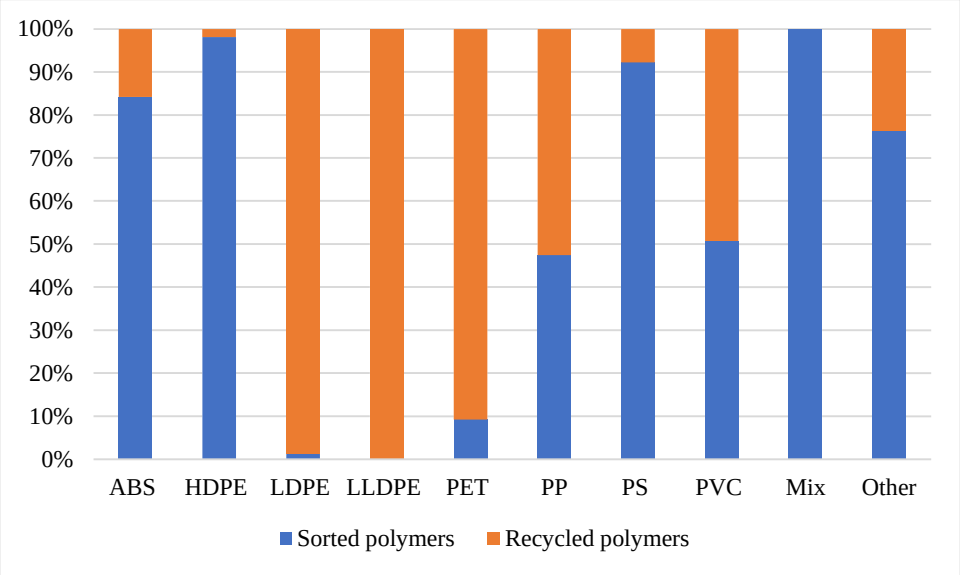


Fig. 15 – Partial remanufacturing capacity of plastic materials

3. DISCUSSION

Plastics usage is dominated by few types of polymers, however, each of them are mixed with chemical substances producing a multitude of plastic materials and goods characterized by different molecular composition and formulation (European Commission 2018b). Complex materials and design strongly affect the waste valorization. The amount and the type of plastic waste generated in Emilia Romagna reflects the economy of the region where plastics represents a key material also for business. The so-called packaging valley (and district), composed by more than 300 firms working in packaging and packaging machinery manufacturing, provides the biggest amount of industrial plastic waste. In addition, the phenomena related to urban growth affect also the municipal waste generation. Even if industrial waste (72%) are more than household ones (28%), ERR advances in third place for the total production of municipal waste and in first place for the production per-capita in Italy (ISPRA 2018). Measures on waste prevention should be prioritized (Salhofer et al. 2008; Bartl 2014). Further, the wide variety plastic-based applications reflect the presence in the waste stream composition, challenging the collecting, sorting and recycling performances as evidenced by the big generation of mixed and contaminated plastics. Even if industrial waste are affected by more evenness, the public-private governance and the increasing number in waste consortia and platforms contribute to fragment the waste streams traceability and therefore the monitoring of the regional capacity. Finally, the status of SPs, that are no longer waste, doesn't allow the traceability by official data collection scheme. It follows that the lack of technological, logistic, economic and environmental data, in an aggregated and harmonized form, gets difficult insight to provide a clear picture on recycling, both for municipal and special waste. A rethinking of data collection and elaboration should be carried out in order to provide a clear EoL picture of plastic goods. This intention is also supported by the recent amendment of the WFD that establishes ambitious targets on PCPPW recycling and a unique methodology to harmonize the calculation as well. In fact, while the Decision

2011/753/UE gave the possibility to choose among various methodologies, the Directive 2018/851/UE sets out a specific calculation method where recycling target is based on the amount of plastic waste effectively turned up in secondary plastics (European Parliament and of the Council Directive 2018a). Considering the regional flow through, the total amount of PCPPW sent to recycling and disposal respectively accounted for 62.319t and 70.454t in 2017. It follows that less than half amount of plastic packaging consumed in 2017 are materially recovered. According to the new algorithms, around 90.000t should be additionally recycled to reach the 2030 goal.

4. CONCLUSIONS

The ambitious program established by the European Commission within the Plastics Strategy requires a systemic rethinking of the waste governance. Supporting legislation, facilitating management system and robust financial measures should be advanced in order to boost regional innovation towards the enforcement of an after-use plastics economy. The quali-quantitative analysis of plastic waste management in ERR has pulled out some practical recommendations here listed:

- Promote all type of actions fostering the reduction of plastic waste

- Raise awareness of consumers in order to avoid the PCPPW disposal in the commingled collection

- Implement the Deposit-Refund-System, especially for PET bottles with the aim to reduce the contamination in one hand and maximize the profitability of rPET market in another

- Promote eco-design through training activities and financial measures thus supporting the reduction of mixed and contaminated plastic waste that represents the main cost and environmental impact of the waste management

- Harmonize data collection among national and independent consortia

- Initiate focus groups discussing the introduction of actions aimed to monitor the flow through of SPs at first and the implementation of industrial synergies then

- Support remanufacturers to produce recognizable high-quality SPs and monitor the performance through value-based metrics

- Invest on new industrial recycling infrastructure ensuring the fulfillment of the regional demand

In order to incorporate all these considerations, a participative stakeholder's path is necessary. This work represents only the first step working in this direction. Authors are actually working on the future scenario envisioning and strategy planning able to capture the intrinsic value of plastic materials and create a profitable business of SPs.

HEADINGS

• Data on Plastic waste are not harmonized. A clear picture on plastic waste management is difficult to define.

• The increasing complexity in products design and the lack of transparency on the material composition struggle to guarantee a high quality of secondary plastics.

• Investments on eco-design and recycling could support the profitability of plastic waste and secondary plastics market.

ABBREVIATIONS

ANCI National Municipalities Association

ARPAE Regional Agency for Prevention, Environment and Energy

AT Austria

C&D Construction & Demolition

CC Centri Comprensoriali

CN China

CONAI Post-consumer packaging waste Consortium

COREPLA National Consortium for the Collection and Recycling of Plastic packages

CSS Centri di Selezione e Smistamento – *Selection and Sorting Centres*

CZ Czech Republic

DE Germany

ELVs End-of-Life vehicles

EoL End-of-life

EPR Extended Producer Responsibility

ERR Emilia-Romagna Region

ES Spain

EWC European Waste code

FR France

HD-PE High density Polyethylene

HR Croatia

HU Hungary

ID Indonesia

IN India

LD-PE Low-density Polyethylene

LV Latvia

MSW Municipal Solid Waste

MUD Modello Unico di Dichiarazione Ambientale

MY Malaysia

NL Netherlands

ORSo Osservatorio Rifiuti Sovraregionale

PCPPW Post-consumer plastic packaging waste

PEPS Platform for PS_based waste

PET Polyethylene Terephthalate

PIA Platform for general industrial packaging waste

PIFU Platform for drums and tanks

PL Poland

PO Polyolefin

PPW Plastic Packaging Waste

PS Polystyrene

RO Romania

SI Slovenia

SK Slovakia

SPs Secondary Plastics

SUPs Single-Use-Products

SW Special waste

TH Thailand

TR Turkey

UNIBO University of Bologna

VN Vietnam

WFD Waste Framework Directive

WMS Waste management system

ACKNOWLEDGMENTS

The investigation has been carried out within the action plan of the Interreg Europe project named TRIS – Transition region towards industrial symbiosis. A special thank is due to Manuela Ratta (RER) for giving us the possibility to investigate the regional waste management system. Authors would also thank Maria Concetta Peronace and Annamaria Benedetti (ARPAE) for providing data and useful explanation about plastic waste generation and management in Emilia Romagna Region (Italy). Finally, authors would like to thank COREPLA for giving us data about the management of municipal plastic waste.

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