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Research article

Model for the separate collection of packaging waste in Portuguese low-performing recycling regions

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ABSTRACT

Separate collection of packaging waste (glass; plastic/metals; paper/cardboard), is currently a widespread practice throughout Europe. It enables the recovery of good quality recyclable materials. However, separate collection performance are quite heterogeneous, with some countries reaching higher levels than others. In the present work, separate collection of packaging waste has been evaluated in a low-performance recycling region in Portugal in order to investigate which factors are most affecting the performance in bring-bank collection system.

The variability of separate collection yields (kg per inhabitant per year) among 42 municipalities was scrutinized for the year 2015 against possible explanatory factors. A total of 14 possible explanatory factors were analysed, falling into two groups: socio-economic/demographic and waste collection service related. Regression models were built in an attempt to evaluate the individual effect of each factor on separate collection yields and predict changes on the collection yields by acting on those factors. The best model obtained is capable to explain 73% of the variation found in the separate collection yields. The model includes the following statistically significant indicators affecting the success of separate collection yields: i) *inhabitants per bring-bank*; ii) *relative accessibility to bring-banks*; iii) *degree of urbanization*; iv) *number of school years attended*; and v) *area*.

The model presented in this work was developed specifically for the bring-bank system, has an explanatory power and quantifies the impact of each factor on separate collection yields. It can therefore be used as a support tool by local and regional waste management authorities in the definition of future strategies to increase collection of recyclables of good quality and to achieve national and regional targets.

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1. Introduction

Separate collection of packaging waste (glass, paper/cardboard and plastic/metal) is currently in place throughout Europe. This practice enables the recovery of recyclables of higher quality than those recovered from unsorted waste at mechanical and biological treatment facilities (MBT). The quality is important in the perspective of further re-integration of the recovered materials in

production cycles as secondary raw materials. Average separate collection performance of glass, paper/cardboard, plastic/metal and bio-waste from residual waste/mixed municipal waste in the capital cities of the 28 European Union member states was 18.6% in 2015, but performances were quite heterogeneous across the 28 cities (Fig. 1) (European Commission, 2015).

A coastal region in the centre of Portugal where bring-bank separate collection schemes are being used and monitored was selected for this study. The separate collection of packaging waste from households in this region in 2015 was 7.6%, standing well below the EU-28 capital cities average of 18.6% (Fig. 1). Consequently, in this region, separate collection still has a significant potential for improvement and needs to do so. Separate collection

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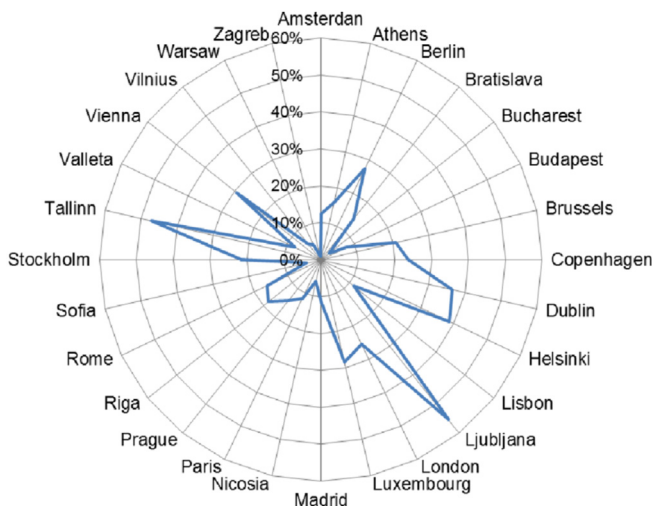


Fig. 1. Separate collection performances in EU-28 capital cities (European Commission, 2015).

is one of the objectives of the Portuguese Strategic Plan for Municipal Solid Waste Management (MAOTE, 2014), approved in 2014 following European Union regulations (Directive 2008/98/EC, on Waste, currently under revision (European Parliament and of the Council, 2008); Directive 99/31/EC on Landfill Waste (European Council, 1999); and Directive 2004/12/EC on Packaging and Packaging Waste (European Parliament and of the Council, 2004)). In 2015, the European Commission proposed a new Circular Economy Package where new targets were established for 2030: i) reduction of landfilling to a maximum of 10% of municipal waste; ii) increase re-use and recycling of municipal waste to 65%, iii) increase recycling of packaging waste to 75% and iv) ban on landfilling of separately collected waste. Given the low separate collection performance of coastal region in the centre of Portugal, the pressures to attain National and European targets related to waste recycling are even more critical, justifying furthermore the context for the present research.

Previous studies on separate waste collection have addressed the environmental, economic and social costs and benefits in the recycling system (Da Cruz et al., 2014, 2012; Ferrão et al., 2014; Ferreira et al., 2014a), the identification and analysis of engineering indexes for municipal solid waste (MSW) management systems (Gamberini et al., 2013), the economies of density and size in municipal solid waste recycling (Carvalho and Marques, 2014), the economic viability of packaging recycling (Marques et al., 2014) and the viability of implementing the separate collection of bio-waste in restaurant and canteens (Rodrigues et al., 2015). Technical aspects related to the characterization of waste collection systems and operation performance of separate collection were also analysed by Rodrigues et al. (2016) in the Greater Lisbon area, in Portugal, by Gallardo et al. (2012, 2010), in Spain. In addition, a robust non-parametric method based on conditional order-m efficiency was used by Guerrini et al. (2017) to assess the performance of drivers in MSW services in 40 municipalities in Verona province, Italy.

The Waste and Resources Action Programme (WRAP) evaluated the performance of kerbside dry recycling in the UK during 2008/09 (Wrap, 2010). In this work, a model was put forward in which three factors accounted for 42% of the variation in recycling yields, namely the levels of deprivation (higher levels of deprivation leading to lower performance), the range of materials targeted (more materials leading to higher collection yields) and frequency

of refuse collections (fortnightly refuse collection leading to higher performance in dry recycling collection in comparison to weekly refuse collections) (Wrap, 2010). The contribution of kerbside collection to the increase of separation rates of paper and plastic has more recently been assessed also in some municipalities of the Czech Republic (Struk, 2017), together with other factors (higher density of drop-off sites and existence of incentive programs).

In Portugal, the main collection system for separate recyclable is the bring-bank system, as opposed to the kerbside collection in use in other countries. The difference between them is that while in kerbside collection (also called “door-to-door”) each household has its own waste container that is placed outside the household, on the kerbside, for collection, in the bring-bank system the waste is placed in larger collective containers at the road side (Fig. 2). Since no study was found evaluating the factors influencing separate collection for the case of bring-bank collection system, the present research is a contribution to fill this gap. The objectives are: i) to identify and quantify the relevant factors affecting the success of separate collection services; and ii) develop a model specific for simulating the performance of the bring-bank system.

The remainder of this work is organised as follows: Section 2 introduces the study area; section 3 presents the methodological approach used; Section 4 presents and discusses the results; and Section 5 lays out the conclusions and relevant implications of this work.

2. Study area

The study area (Fig. 3) is located in the coast of the “Centro” Region of Portugal, bordered by Oporto in the North and by Lisbon in the South. It comprises 42 municipalities, a population of 1,245,241 inhabitants (12% of the total Portuguese population) and covers an area of 8848 km² (9.6% of national territory). This region has economic and socio-cultural similarities with various areas away from the main urban centers in the Mediterranean countries (e.g., Spain, Italy, Greece).

The main flows for municipal solid waste in the study area are presented in Fig. 4, showing that almost 500,000 tonnes were discarded in 2015 (data compiled from ERSUC (2016) and VALORLIS (2016)), representing roughly 10.4% of all municipal solid waste in Portugal (APA, 2016).

Separate collection of packaging waste in this region is carried out by two multimunicipal waste management companies, “ERSUC, S.A.” (hereafter referred as ERSUC) and “VALORLIS, S.A.” (hereafter referred as VALORLIS). The main separate collection process for household packaging waste in the study area is bring-banks (95.7%), so called “ecopoints” depicted in Fig. 2a). Civic amenity recycling sites are enclosed sites or buildings where citizens can drop-off different recyclable fraction, such as packaging waste, wood, household hazardous waste, electric and electronic waste, garden waste and others. These civic amenity recycling sites are responsible for the collection of the remaining 4.3% of separately collected packaging waste in the study area (ERSUC, 2016; VALORLIS, 2016). The bring-bank usually comprises 3 units: i) a blue container for paper/cardboard packaging; ii) a yellow container for plastic/metal packaging; and iii) a green container for glass packaging. Collected material is delivered at three integrated centers for treatment and recovery of municipal solid waste. These centers are managed by the multimunicipal waste management companies of the study area, ERSUC and VALORLIS. Packaging materials sorted at these integrated centers are then sent for recycling through SPV – “Sociedade Ponto Verde”, Portugal’s non-profit organisation responsible for recycling packaging waste established under the framework of extended producer’s responsibility. The SPV finances the collection and separation of

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