Environmental considerations on MSW collection. A local case of study through LCA application.

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Among the three main stages of Municipal Solid Waste (MSW) management – namely: collection, transport and treatment or disposal – collection is typically considered as a critical activity with regard to the significant costs derived from the fuel consumption of collection vehicles. In Portugal, it is reported that 79% of environmental budget in municipalities is spent on waste collection (Teixeira, Avelino, *et al.*, 2014).

A number of studies have been published (Teixeira, Avelino, *et al.*, 2014; Teixeira, Russo, *et al.*, 2014; Rodrigues, Martinho and Pires, 2016a, 2016b; Ferreira *et al.*, 2017; Martinho *et al.*, 2017; Pires *et al.*, 2017) with the goal of assessing and benchmarking the performance of MSW collection systems in Portugal, which is a necessary step in order to locate possible inefficiencies and ways for potential improvement. This work runs in parallel with the efforts required for meeting the recycling targets set by environmental legislation (Ministério do Ambiente, Ordenamento do Território e Energia, 2014); (ERSAR, 2016). Within this general context, and under the scope of the LIFE PAYT project – funded by the European Commission and intended to the implementation of variable PAYT ("*pay-as-you-throw*") pricing schemes for MSW tariffs in Southern European municipalities –, a study of the unsorted MSW collection system in the Portuguese coastal city of Aveiro was performed, making use of Life Cycle Assessment (LCA). Thanks to its capacity to identify the environmentally critical points within a given process, this methodology has become a common practice to analyse performance of waste management (Pires, Martinho and Chang, 2011), as shown by an increasing number of applications (Laurent, Bakas, *et al.*, 2014; Laurent, Clavreul, *et al.*, 2014). In the specific case of MSW collection, LCA has been applied for comparison of different collection systems (Iriarte, Gabarrell and Rieradevall, 2009; Punkkinen *et al.*, 2012; Aranda Usón *et al.*, 2013) or analysis of a particular element of the system, such as container types (Rives, Rieradevall and Gabarrell, 2010) or fuel consumption by vehicles (Larsen *et al.*, 2009).

In this present work, the LCA methodology – as described by ISO 14040 – was applied to analyse the unsorted MSW collection for a particular residential neighbourhood in the city of Aveiro, which was selected by the municipality to be part of a pilot experience for the future implementation of a PAYT MSW tariff. The functional unit selected for the study was the annual generation of unsorted (residual) MSW in the neighbourhood, which was estimated from a waste characterisation campaign performed during four days.

For the elaboration of the Life Cycle Inventory (LCI), four elements were defined as main constituents of MSW collection process: dustbins used to keep rubbish at households, plastic bags for carrying waste to the street, street containers to put together the rubbish bags and finally, the actual collection and transport process using a MSW collection lorry. Inventory data were obtained from the municipality and completed with life cycle databases and other bibliographical sources.

Results of the Life Cycle Impact Assessment show that for all the impact categories selected, the two main contributors to the environmental impact are the utilisation of plastic bags and the collection and transport activity with the lorry. Plastic bags are the top contributor regarding freshwater eutrophication, human toxicity, marine ecotoxicity and fossil depletion, while the collection with lorry has the highest contribution for climate change, terrestrial acidification and photochemical oxidant formation.

The relative high impact associated to the plastic bags can be explained by their relative short shelf life when compared to the other items: dustbin, containers and collection lorry. Moreover, it has been considered that the final destination of a large majority of bags is disposal in a sanitary landfill, which is a major source of long-term emissions to the environment. Consumption of fossil raw materials required for production of polyethylene also plays a significant role. A sensitivity analysis was performed to reflect the influence of different bag features – i.e. size and weight – and different patterns of use. Given the relative high impact of the plastic bags, alternative scenarios were tested, namely the use of bags entirely produced with recycled polyethylene – which allowed to prevent the impacts related to production processes, but did not avoid the effects of disposal in landfill – and the use of bags produced with bioplastics derived from starch – which did not present a harmful behaviour in landfill, but on the other hand were a source of major emissions as a consequence of agricultural practices – .

Concerning the fuel consumption by collection vehicles, a comparison was performed between real fuel consumption data supplied by the municipality and the fuel consumption assumed in the ecoinvent 3 database for the MSW collection process. A significant difference between the two sources was found, the collection in the studied area consuming roughly twice the fuel estimated by the model. With this result, at first impression it could be said that the collection route under study seems to be inefficient. However, in a further comparison several other studies in different locations showed results closer to the case of study. The difference may be explained by site-specific conditions, thus showing the importance of obtaining real data at a local level (instead of using model data from the databases) in order to get accurate results.

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