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Environmental analysis of different packaging waste collection systems for Istanbul – Turkey case study

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ABSTRACT

Source-separated collection of recyclable packaging wastes has been a huge issue for cities such as Istanbul considering their socially, economically, culturally and environmentally cosmopolite structure. In order to apply an environmentally effective separation and collection, system has to be analyzed with a holistic approach including whole recycled packaging material amounts, source consumptions and related emissions. In this context, the aim of this study is to determine the environmentally optimum source-separated packaging waste collection system applicable in Istanbul, Turkey for the first time in literature. Eight scenarios for separated collection system were defined and all of them were compared with each other and with the existing system. To measure the efficiency of the system, some efficiency indicators were chosen and effectiveness related variables were determined to predict the participation rate. Calculations of the efficiency indicators for alternative scenarios were based on the existing system. The environmental analysis was conducted by using Life Cycle Assessment methodology. The results of this study showed that existing system was still one of the environmentally most promising scenarios. Following advantageous scenarios were Scenarios 5 and 6 which were two and three fractionated curbside collection systems, respectively. It is also seen that more fractionated scenarios were less beneficial than two fractionated scenarios. And finally, it can be concluded that with an increment on participation rate and changing collection material type, collection efficiency of curbside system would increase and be environmentally more beneficial.

1. Introduction

Municipal solid waste management system (MSWMS) is defined as "the discipline associated with the control of generation, storage, collection, transportation, processing and disposal of municipal solid waste, in a way that is governed by the best principals of public health and economic, engineering, esthetic and other environmental considerations" (Al-Maaded et al., 2012).

Management of a municipal solid waste (MSW) starts with the collection of waste generated in residential, multifamily, and commercial sectors. The MSW is then transported for separation and recycling, treatment, or disposal facilities (Weitz et al., 1999). Each stage of an integrated waste management system involves a different management-operation strategy for itself. To achieve an optimum efficiency in a MSWMS, it is important to analyze each stage's requirements. In this management process, a well-organized separate collection stage increases the entire systems' efficiency.

In Turkey, waste management has been a subject of legal arrangements since 1930s with the publication of "Public Hygiene Law" (UHK, 1930) and municipalities have been assigned as the main implementation authority with the publication of "Municipality Law" (BK, 1930). However, there were not any obligations on separation of recycling materials, until the publication of Regulation on Control of Solid Waste in 14.03.1991 on Official Gazette No.: 20814 (KAKY, 1991). Moreover, with the publication of Regulation of Controlling Packaging Waste in 2004, municipalities became responsible and within the scopes of negotiation with EU, there have been considerable improvements in solid waste management regulations in order to meet the targets in the European Union's Directive.

The recyclable packaging wastes in Turkey are mainly collected by door-to-door system, which is carried out by municipalities.

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However, a large proportion of recyclable packaging wastes are collected by scavengers, who are described by Sanneh et al. (2011) as the citizens with low to no income that collect materials either dispersed throughout the city or concentrated at dump sites. Agunwamba (2003) stated that because of the social, cultural, financial and environmental conditions, the implementation of the source separation of recyclable materials in Nigeria may not be an effective system considering the investment cost, requirement of public education and expertise of the system. Therefore, integration of the scavengers into the system was suggested as a solution. However, this is an uncontrolled and informal collection system which has numerous social disadvantages such as health risk, low income, child labor, etc. In addition, contamination of waste decreases efficiency of recyclable material. All these above stated issues have directly increasing effect on social and environmental impact, thus scavengers' method is not considered as an option for packaging waste collection system in this study.

Recently, Environment and Urbanization Ministry published Regulation of Waste Management (AYY, 2015) which includes "Waste bring centers and a plan of double type collection of household solid waste (organic waste and packaging waste)". Waste bring centers and double type collection system suggested by local authorities have been discussed as a draft circular from 2011 till now to determine the responsibilities of stakeholders and to achieve a source separated packaging waste collection system. However, although there are various changes in the law and regulations, there is not a well-defined waste management system which is fully-supported by the regulations yet. So, stakeholders such as municipalities and private companies cannot apply an effective separate collection of packaging waste which is the most important part of the waste management system. Therefore, local authorities are still trying to develop a sustainable packaging waste management policy. In order to achieve an effective packaging waste collection system, regional differences (urbanization), social awareness, economic conditions and environmental benefit should be analyzed in detail.

Gallardo et al. (2012a) indicated that efficiency of a separate collection system was influenced by a number of factors which are mainly environmental, economic, social, political, legal and technological factors. Also, to achieve an increment on the collection efficiency of recyclable materials, it was important to analyze citizens' behavior with regard to the various collection systems: the level of participation, quality of the waste collected, financial incentives, etc. For the social aspects of the system, Martin et al. (2006) carried out a detailed review of approaches taken in England to encourage households to participate in recycling and McDonald and Ball (1998), Read (1999), Dahlén et al. (2007), and Thomas (2001) also studied on public participation in England. For instance, Perrin and Barton (2001) found that providing the correct collection scheme design to households not only retains a higher proportion of households who anticipate using a curbside recycling scheme but also captures the traditionally "non-committed recycler" ensuring maximum participation rates and high diversions of recyclable materials. Kaciak and Kushner (2009) determined the factors that influence recycling behavior and examined the socio-demographic characteristics of participants in some regions of Canada. Also, Omran et al. (2009) and Otitoju (2014) researched the individual attitude of participants in Malaysia and Nigeria, respectively. Gellynck et al. (2011) identified 12 variables to increase recycling and reducing the residual household waste in Belgium. Also, Heravi et al. (2013) compared different recycling collection scenarios in Tehran, considering the source consumption, cost benefit, public acceptability, and risk assessment of the scenarios. Above given literature researches, mainly examined the efficiency of source separation system related with multiple variations. Generally, main purpose on these literature researches was to make an increment on the amount of recyclable materials or to determine reason of the current situation. However, even if increasing the amount of the recyclable materials have an important positive effect on the ecosystem; it has also a negative effect arising from the collection system which consumes resources and releases emissions. Therefore, it is important to analyze the system with a holistic approach.

The environmental, economic and social analysis of the municipal solid waste management systems is generally conducted using the Life Cycle Assessment methodology. Many of LCA applications in this field are focused on the use of this methodology as a decision support tool in the selection of the optimum system and it is commonly used through the world on any stages or whole stages of MSWMS (Özeler et al., 2006; Rives et al., 2010; Banar et al., 2009; Menikpura et al., 2012a,b; Hong et al., 2010; Bovea and Powellb, 2006; Skordilis, 2004; Soderman, 2003; Weitz et al., 1999; Rigamonti et al., 2009; Guereca et al., 2006; Gomes et al., 2008; Boer et al., 2007; Rebitzera et al., 2004). For example, Teerioja et al. (2012) compared social life cycle costs of a stationary pneumatic waste collection system to a vehicle-operated door-to-door collection system in Finland and found that traditional door-to-door system economically had more advantages than pneumatic system. Bovea et al. (2010) studied on the environmental life cycle of 24 waste management scenarios which were consisted of pre-collection (bags and containers), collection, transport, pretreatment (waste separation) and treatment/disposal stages. Iriarte et al. (2009) quantified and compared the potential environmental impacts of mobile pneumatic, multi-container and door-to-door collection systems and found that, the collection system with the least impact was multi-container collection system whereas door-to-door and mobile pneumatic systems had the greatest impact at the urban subsystem level. Rigamonti et al. (2009) evaluated how different assumptions about recycling system influenced the LCA results of integrated waste management system and indicated that source-separated collected materials had a great influence of the whole management system as 15% decrease on the selection efficiencies resulted in 26% increase on global warming effect of the system. Larsen et al. (2010) carried out environmental and economic assessment of five alternative collection systems with the different efficiency for collecting recyclables in Denmark and found that curbside collection would be environmentally more beneficial than drop-off and bring centers. Giugliano et al. (2011) analyzed four scenarios of separate collection system including drop-off collection systems with 35 and 50% overall separation and curbside collection systems with overall separate collection value of 50 and 65%, and found that 50% separate collection system was the best performing scenario. Until this year, as Laurent et al. (2014a,b) indicated, only Banar et al. (2009) and Özeler et al. (2006) used the LCA methodology to determine the optimum municipal solid waste management system in Eskisehir and Ankara, Turkey. Recently, Erses Yay A.S (2015) published a similar study for Sakarya, Turkey. In these studies reported for Turkey, the entire municipal solid waste management system was analyzed. However, for Istanbul it is not always possible to reach realistic data to analyze the entire system since each stage of the MSWMS handled by different responsible institutions. For this reason, only collection, transportation and treatment processes of recyclable packaging waste were investigated to offer a solution to decision-makers from a more environmentally effective point of view. This study analyzes and compares the current and alternative scenarios in terms of environmental effectiveness of a separate collection system of recyclable packaging waste as a part of integrated waste management system for the first time in Turkey.