



Informal collection, recycling and export of valuable waste as transcendent factor in the municipal solid waste management: A Latin-American reality

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ABSTRACT

The informal collection, storage, and commercialization of Valuable Solid Waste (VSW) performed by waste pickers is a complex and dynamic socioeconomic phenomenon. In developing countries, the waste pickers play a major role as suppliers to companies dedicated to the commercialization of VSW, thus contributing to mitigate the environmental impact of the municipal solid waste management (MSWM) systems. This research work presents the logistic and geographical structure of the informal collection, commercialization, and national and international recycling of VSW recovered from a medium size city in Mexico. The life cycle assessment methodology is used to determine the environmental impact that recycling VSW from informal collection has on the MSWM system. The functional unit is defined as the management of one ton of municipal solid waste. The functional unit displays a climate change index of 1090 kg CO₂ eq, while the recycled VSW has the potential to mitigate it by -116.5 kg CO₂ eq. The marginalization index is a way to assess the socioeconomic condition of the waste pickers. This index shows that the waste pickers suffer high marginalization, despite the fact that they contribute with 72% of the total collection of VSW.

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1. Introduction

Municipal solid waste management (MSWM) is a complex problem that mainly affects underdeveloped and developing countries. The Mexican government has established models for

MSWM as part of its legislation, where actions aimed at reducing the disposal of MSW in sanitary landfills (SL) are considered. These include actions such as waste production minimization, waste classification at the source, reuse and recycling of valuable solid waste (VSW), as well as material and energy valorization of the waste (SEMARNAT, 2008).

Between 2000 and 2010, the generation of MSW in Mexico grew 30.26%, compared to a 15.17% population increase for the same period. This resulted in a generation of 40.1 million tons of MSW in 2010. During this period, the gross national product grew 33.1%, while the waste generation *per capita* went from 0.83 to 0.93 kg/day (SEMARNAT, 2012). MSW generation displays a complex relationship with the economic development and population dynamic of a

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society (Chen et al., 2010).

According to SEMARNAT, in 2012, 72% of Mexico's MSW was disposed in SL and other regulated sites, 23% was taken to open landfills, and the remaining waste was recycled. In the same year, there were 260 SL in operation that fulfilled the required regulations (SEMARNAT, 2012).

In the last years, the collection, storage and recycling of VSW has been encouraged, since it went from 2.3% in the year 2000 to 5% in 2012 (Góngora-Pérez, 2014). Although, this is still far behind compared to other countries: the world's average is 19% (Gutberlet, 2015), 25.3% in the European Union (da Cruz et al., 2014), and 8–10% in China (Chen et al., 2010).

The collection, storage, commercialization, and recycling of VSW in Mexico have increased due to the price and demand hike of polyethylene terephthalate (PET), paper, cardboard, and metal scraps. Since 2015, Mexico has become the main recycler of PET in Latin-America, since it salvages 50.4%, equivalent to 722,000 t, of PET present in the MSW. From these, 40% were shipped to China and the rest were reprocessed in Mexico in 15 different facilities, with a total processing capacity of 300,000 t/year (ECOCE, 2017). In the year 2012, 3.2 million tons of paper and cardboard were recovered, 1.6 million tons were imported, and only 177,000 tons were sold to China (CNICP, 2012).

The MSWM systems in developing countries are generally inefficient since they lack the proper administrative and financial structures, good regulations, infrastructure, and adequate human resources. The informal collection of VSW done by waste pickers is a partial solution to these problems, despite the fact that this activity has a negative social perception (Navarrete-Hernández and Navarrete-Hernández, 2018). Approximately, 1% of world's urban population is involved in the recovery of VSW; in Latin America, Asia, and Africa, the work of these people accounts for nearly 30% of the VSW recovery process (Gutberlet, 2015).

The different forms in which the recovery of VSW are done by the waste pickers and their importance have been studied mainly in Brazil (Tirado-Soto and Zamberlan, 2013), and in Asian countries (Asim et al., 2012). Brazil is taking steps toward the recognition and formalization of the waste pickers activities, through urban co-operatives or unions, and public regulation (Gutberlet, 2015). The creation of waste pickers' cooperatives has the potential of improving their conditions by allowing them to demand their rights, improve the collection of VSW, and negotiate a better sales price for the collected VSW. Additionally, it provides an opportunity to educate the waste pickers on how to handle hazardous waste, such as electric and electronic devices (Ghisolfi et al., 2017). Thus, knowledge of their daily income, living and working conditions, and the hierarchical structures among the waste pickers groups, are required to improve their social inclusion and work formalization (Sasaki et al., 2014).

In Mexico, the recovery of VSW is fundamental for the recycling companies, and for the national and international trade market of products such as PET, paper, aluminum, and other materials. Nevertheless, official information on this activity is scarce. A study done in 2008 about informal collectors that worked in 15 SL found that their socioeconomic condition has improved compared to the one from the 1990's. A 71% of the waste pickers owned a house build with bricks and concrete, 52% have attended middle school and 23% elementary school, and infant work has declined. Regardless of these improvements, the waste pickers are still a marginalized sector of society (Niño and Hernández, 2012). This marginalization is associated to a lack of social opportunities, and skills needed to acquire or generate such opportunities, as well as privation and lack of accessibility to basic goods and services required for well-being (Almejo-Hernández et al., 2013). The social impacts are a consequence of the positive or negative pressure from

the surroundings on the well-being of the different participants in the various stages of a process. Currently, the social impact can be evaluated with a focus on life cycle assessment (LCA) (UNEP, 2009). In this work, we use the measured marginalization as a social impact indicator.

In order to achieve sustainability in modern societies, the recycling of MSW is essential. Thus, MSWM systems must be directed to strengthening the markets and the recycling industries (Exposito and Velasco, 2018). Nevertheless, as it has been mentioned, the collection and availability of VSW as input to the recycling industries in the developing countries, depends to a great extent on the work done by the waste pickers. In many countries, this activity has not been characterized, nor its relevance on the sustainability of the urban areas has been systematically evaluated. A more in-depth knowledge of this activity is essential to regulate, legislate, and above all improve the quality of life and the social inclusion of the waste pickers. The objective of this work, is to characterize and evaluate the structure of the informal collection, storage and commercialization of VSW in the City of Celaya, in central Mexico, using the LCA methodology. With the aim of objectively estimate the contribution of the recycling industries in the environmental impact reduction of the MSWM system. Additionally, the socioeconomic condition of the waste pickers as a social group is evaluated through a marginalization index. This information is useful and fundamental to generate public laws and programs to dignify the work of the waste pickers.

2. Material and methods

This research work follows the LCA methodology. Sections 2.1 and 2.2 explain the objective and breath of the research, Section 2.3 expands on the analysis for the life cycle inventory, and Section 2.4 covers the evaluation of the social and environmental impacts.

2.1. Socioeconomic description of the city of Celaya

The City of Celaya is part of Celaya's county, in the state of Guanajuato, and is located in the north central region of Mexico, Table 1 shows some features of the City of Celaya. The main economic activities are divided between the service industry (66%), the secondary sector (26%), and the primary sector (8%). The secondary sector has been growing continuously due to the investments in several industries, such as agro-industry, food, metal working, and more recently automobile production (Cobarrubias-Valdenebro, 2014). The county has an estimated economic growth between 3.9 and 4.2%

2.2. Description of the municipal solid waste management system

The information needed for this work was put together from different sources, namely the Government of Celaya (2012–2015)

Table 1
Main characteristics of the City of Celaya.

Feature	Amount
Geographic location	Latitude: 20° 31'24" N Longitude: 101° 48' 55" W
Total area	553.18 km ²
Total population	468,469 inh
Urban population	72.66%
Rural population	27.34%
Economic activities	
Service industry	66%
Secondary sector	26%
Primary sector	8%

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