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CO2ZW: Carbon footprint tool for municipal solid waste management for policy options in Europe. Inventory of Mediterranean countries

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HIGHLIGHTS

- ► We present a new tool, CO2ZW, for GHG emissions calculations from MSW management.
- ► The tool includes default national values of Spain, Italy, Slovenia and Greece.
- ► We conduct a sensitivity assessment and a comparison with tools already available.
- ► We evaluate waste management choices depending on waste infrastructures and policies.
- ► Quantification of GHG emissions is key for waste options and climate change solutions.

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ABSTRACT

In the frame of the European project titled "Zero Waste" (1G-MED08-533), a tool has been developed called CO2ZW for estimating the GHG emissions for the management of MSW at the municipal, regional or national levels with small amounts of input data. The objective of this paper is to demonstrate that the CO2ZW tool allows us to inventory and monitor GHG emissions from MSW following the IPCC guidelines for national inventories and the principles of life cycle assessment (LCA). The CO2ZW tool includes the key stages and parameters for calculating GHG emissions and includes several advantages regarding the implementation of the default values of the Mediterranean European countries, an improvement in accessibility (online free access) and two approaches for calculating GHG emissions from landfills. The results of this paper show that for countries with medium and high rates of deposition, implementation of the European policies limiting waste in landfills can contribute to mitigate climate change in a remarkable way. With the CO2ZW tool, it is possible to evaluate waste management choices depending on waste management infrastructures and waste policies, along with the quantification of GHG emissions from MSW management, which is essential to guide waste policy options and climate change solutions.

1. Introduction

With the global urban population now exceeding 50%, the inhabitants of cities are recognized as the major drivers of global greenhouse gas (GHG) emissions. Moreover, as centres of wealth and creativity with high population densities and economies of scale, cities must play a significant role in tackling global climate change (Kennedy et al., 2009). Concerns regarding global climate change have resulted in the development of a variety of solutions to monitor and reduce emissions on the global and local scales. For instance, the EU energy and climate package has set goals to reduce these GHG emissions by 20% by 2020, with an option to increase the reduction target to 30% if a comprehensive international agreement is reached, and the results of an analysis of several options have been recently published (European Commission, 2012). Municipalities are often in a position to make decisions that affect the local emissions in the short, medium and long terms. Therefore, the possibility of quantifying local emissions has become an important element in understanding the problem (D'Avignon et al., 2010), and there is a crucial need to present a suitable method for accounting for GHG emissions at the city level so that urban decision makers can develop appropriate policies to reduce their total GHG emissions (Xi et al., 2011).

Over the last 20 years, GHG emissions have resulted from two sets of opposing factors: those increasing the GHG emissions and those helping in mitigating emissions (Dimitroulopoulou and

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Ziomas, 2011). In this sense, at a global scale, the waste management sector makes a relatively minor contribution to greenhouse gas (GHG) emissions, which is estimated to be approximately 3–5% of the total anthropogenic emissions in 2005. However, the waste sector is in a unique position to transition from being a minor source of global emissions to becoming a major saver of emissions (United Nations Environmental Program (UNEP), 2010) due to prevention, reuse and recycling. Although minor levels of emissions are released through waste treatment and disposal, the prevention and recovery of waste (i.e., as secondary materials or energy) avoids emissions in all other sectors of the economy (United Nations Environmental Program (UNEP), 2010). Waste management (WM) has been a focus of the environmental policies of the European Union (EU) since the early 1970s, and their targets and objectives have increased each year. These policies, which require more efforts to reduce, reuse and recycle waste, are helping to close the loop on the use of materials throughout the economy, including life cycle thinking to waste management (Pires et al., 2011). With the intention of improving these principles of reuse and recycling, the project titled "Low Cost—Zero Waste Municipality" bearing the acronym "ZERO WASTE" (1G-MED08-533) was started in 2009, and for 36 months, the partnership including 7 partners from Greece, Italy, Slovenia and Spain has been working on the dissemination of knowhow and data collection to facilitate municipalities in the application of methods to decrease waste. The project aims at developing an integrated zero waste management system for municipalities based on reusing, recycling and reducing waste that ends up in landfills. As a consequence of the project and previous studies (Fragkou et al., 2010; Rives et al., 2010; Iriarte et al., 2009; Muñoz et al., 2004), recent information regarding quantity and quality of the waste management sector of the partners' countries was collected and inventoried. Taking into account the possibility of having to address climate change and the variable quality of the information that has been collected over the years, one of the objectives of project ZERO WASTE was to develop a tool to inventory, describe and quantify the GHG emissions for the management of MSW and to aid in the decision process involved in generating local policies of waste management. The new tool named "Carbon Footprint Tool for Waste Management in Europe" (from now on, CO2ZW) will allow municipalities to inventory and monitor the GHG emissions for the management of MSW following the Intergovernmental Panel on Climate Change (IPCC) (2006) guidelines for national inventories and the principles of life cycle assessment (LCA) (ISO 14040, 2006); to evaluate MSW plans, programs, projects or policies at different scales (i.e., national, regional, municipal); and to detect weak points and potential areas for the improvement of MSW management.

Life cycle thinking in waste management systems has been used as an input to decision making concerning resource priority (Cherubini et al., 2009), and the popularity of applying the LCA methodology to analyze MSW management strategies is illustrated by the numerous published studies as well as by the substantial number of LCA computer models addressing MSW management (Eriksson and Bisaillon, 2011). However, most of these models and tools have been developed to work at the scientific level, and a large quantity of data is required, which in most cases, is not available for local authorities. The CO2ZW tool requires a limited amount of input data and performs calculations that are easy and simple; thus, all stakeholders that are involved in the waste management sector (including technicians, consultants, NGO's or politicians) are able to calculate GHG emissions. CO2ZW also provides three performance indicators to compare the performances of the municipalities with the targets prescribed in the European waste management framework (the overall rate of recycling and the amount of landfilled biodegradable waste and mixed waste without previous treatment sent to landfill). These indicators allow us to evaluate the municipality's performance of legal targets and strategies of climate change mitigation at the same time.

In this paper, we present and describe the CO2ZW tool. We also conduct a sensitivity assessment of CO2ZW to explore uncertainties and to detect critical parameters. Then, we compare the new tool with several tools that are already available. Finally, we evaluate the case of Spain under several scenarios to show the potential abilities of the tool and the GHG emission mitigation.

2. CO2ZW tool description

The CO2ZW is an environmental and management tool for the identification and quantification of emissions of GHG in carbon dioxide equivalents produced over the entire life cycle of the management of MSW. The carbon footprint is defined following the Intergovernmental Panel on Climate Change (IPCC) (2006), ISO 14040 (2006) and PAS 2050 (2011) guidelines. The tool has been designed to function most effectively at the municipality scale; however, it can be used at any scale (including state, country and region) if sufficient data are available. The tool is an Excel®-based calculator, which, with the input of municipality/regional-specific waste data (or national data as a default), permits the user to obtain the GHG emissions of waste treatment processes. Infrastructures are not included since they are assumed to be relatively small in comparison to other stages of waste management (Cleary, 2009). The user will be able to use this tool to support GHG monitoring and for reporting initiatives as well as to provide an estimation of the potential GHG reductions (or additions) associated with the life cycle of waste management and the technological changes in the local waste operations. Input data are required in the assessment tool, but for most of these inputs (except for collection and transport), the tool already contains average default values for the ZERO WASTE project partners' countries (Greece, Italy, Slovenia and Spain). For users seeking to apply this tool within a country external to the ZERO WASTE project, it is advisable to use location-specific data to integrate the countries' own characteristics and features into the calculation. Otherwise, default values based on European averages and estimations from the authors have also been provided.

2.1. Characterization of impacts

The impacts of the global warming potential (GWP) are classified in the CO_2 eq. and disaggregated as direct, indirect and avoided impacts, depending on the type of emission. Direct emissions refer to GHG emissions that take place directly in the system's waste management facilities and are associated with their operation. Direct emissions from treatments have been calculated based on the methodology proposed by the IPCC in the 2006 IPCC Guidelines for the national inventories of GHG (Intergovernmental Panel on Climate Change (IPCC), 2006) widely discussed in next sections. Furthermore, direct emissions are complemented by emissions arising from fuel combustion in waste treatment facilities. Indirect emissions refer to GHG emissions that take place outside of the system's waste management facilities but are associated with their operation (upstream emissions). Finally, the avoided impacts refer to the amount of GHG emissions that has been abated from the system as a result of utilizing recovered and recycled products (both material and energy) from the system's various waste flows in lieu of the same products made from virgin materials. These impacts have been quantified using the CO_2 credits obtained from international and public sources (Comisión Nacional de Energía (CNE), 2010; Boldrin et al., 2009; Prognos, 2008; Jungbluth, 2007a; Kellenberger et al., 2007; Nemecek et al., 2007; US EPA, 2006; and Smith et al., 2001).