



Research article

Introduction of the circular economy within developing regions: A comparative analysis of advantages and opportunities for waste valorization



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ABSTRACT

The introduction of effective solid waste management strategies in developing countries should be considered for improving sustainability at global level. Many barriers should be overcome, concerning the introduction of environmental policies, effective investments, social inclusion and public awareness, which are significant issues in low-middle income countries. The Circular Economy could represent the answer for improving current solid waste management activities worldwide, since denote the principle of waste valorization and recycling for boosting developing economies. This paper is focused on this theme, analyzing main opportunities for improving the current state of solid waste management in developing big cities. The solid waste management of two countries are reviewed: Romania is the emerging country where Circular Economy is becoming a future objective due to economic aids and strength regulations which the European Union (EU) established for the nations forming parts the alliance; as a comparison, Bolivia is reported for evaluating main differences founded for developing recycling systems in a no-EU country. These two case studies could be of interest for highlighting main pros and cons of the participation into a wide organization like the EU for introducing in short terms Circular Economy principles. Moreover, a theoretical Circular Economy model for developing big cities in low-middle income countries is described within the study for effectively comparing which chances can spread for these countries as regard municipal solid waste exploitation. Despite the economic level, Romania and Bolivia are both facing with many solid waste management issues although in different magnitude. For the Romanian case study, it is visible how it cannot achieve the European goals for 2020 due the need of change in public recycling behavior. Bolivia, instead, represents the case where international aids and new investments are required, considering the informal sector into the formal management system as a real opportunity for improving local recycling rate. In conclusion, the comparison suggests how external supports led to implement the principles of the Circular Economy within a developing region. The model of Circular Economy proposed is recommended for developing big cities in order to advance a new form of safe employment, encouraging the activities that are still in action (i.e. informal sector) and boosting the principles of sustainable development.

1. Introduction

Solid waste management (SWM) in developing countries represents a real environmental and social concern since the most applied “treatment” choice is the final disposal in open dump sites or in unsuitable sanitary landfills (Al-Khatib et al., 2010; Ravindra et al., 2015; Maheshi, 2015; Ferronato et al., 2017). Sustainable measures should be introduced, integrating low carbon emission solutions and appropriate

technologies (Papargyropoulou et al., 2015). For that purpose, the shift from a linear to a circular economy (CE) which will preserve the environment, generate new economic growth and spread the ecological awareness of the population, can be considered the most adapt way for improving current SWM worldwide (Diaz and Otoma, 2013).

The theoretical objective and the perfectly circular system will be introduced when longevity of goods equals limitlessness (Franklin-Johnson et al., 2016). For instance, biomass can be always considered

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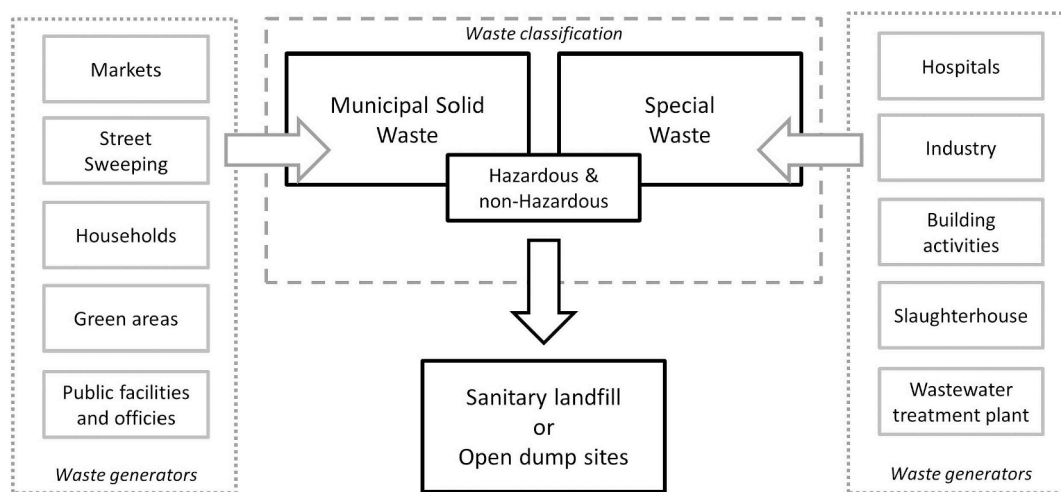


Fig. 1. Categories and sources of solid waste disposed to landfill or open dump sites in low-middle income countries.

in a cyclical flow because all biomass waste products can be re-entered the biosphere (Haas et al., 2015). As stated by Stahel (2016), “a CE system would turn goods that are at the end of their service life into resources for others”. However, every source of waste and every material fraction can be inserted in an autonomous CE scheme, while collection and treatment systems should be assessed differently in cities, towns or small communities, as well as in regions with particular geographical frameworks and touristic areas (Ciudin et al., 2014). For that purpose, municipal and “special” wastes should be evaluated in an integrated manner although, in low-middle income countries, these streams are not differentiated and the environmental impacts due to the solid waste inflow into the final disposal sites are worrisome, since the materials are mixed with hazardous fractions (i.e. hospital waste, oils, slaughterhouse rests) and all waste sources deliver the material at the same collection system (Fig. 1).

For introducing a sustainable CE all management aspects should be considered, such as technical, environmental, health, financial, social and organizational (Zurbrügg et al., 2014), parallel with the inclusion of the population, compulsory for achieving an effective user's acceptance of new SWM systems (Kirkman and Voulvoulis, 2016). For that purpose, the involvement of all the stakeholders and the enforcement of local policies is compulsory (Geissdoerfer et al., 2016). In addition, a successful implementation of CE policy requires efforts at three levels: micro-level (i.e. factories and agricultural products producers), meso-level (i.e. eco-industrial parks and eco-agricultural system) and macro-level (i.e. co-operative networks among industries), where the complexity of practices increase when the scale level rise (Su et al., 2013; Lewandowski, 2016).

The implementation of principles concerning material circularity is intensifying in developed countries (Singh and Ordoñez, 2016; Kirkman and Voulvoulis, 2016) while developing countries are still suffering inappropriate SWM due to the lack of economic funds, public awareness and political will, among others (Marshall and Farahbakhsh, 2013; Wilson et al., 2015). Developing countries like China, Serbia and India started to implement such principles (Geng et al., 2012; Ravindra et al., 2015; Ilić and Nikolić, 2016), although low-middle income countries are commonly introducing projects or management plans with no effective changes (Rada et al., 2010; Ionescu et al., 2015; Esbensen and Velis, 2016).

The aim of this study is to present the main opportunities for introducing the CE in low-middle and middle income developing regions, where recycling systems are not still developed. Two case studies are presented, comparing main difficulties and prospects for implementing the CE. The comparison between Romania, a European Country, and Bolivia, no-European, allows understanding which are the main issues

when policy makers must act in cooperation with a wider organization, by the aid of international funds, or alone. Considerations about this comparison provide an indication of which concerns are detectable in developing countries where regulations and laws are not still adopted and how future guidelines should be deal for the development in environmental, social and economic subjects. Improvements, according to the principles of the CE, are finally suggested as opportunity of economic development.

The paper is divided in three main parts: First, the general background of the two developing countries and of the European Union (EU) are presented, as well as the CE model, highlighting the main actors involved and the topics which are going to be deepened within the results. Secondly, in section 3, the main SWM activities and issues are reviewed both for the two case studies proposed. In this section, the main differences and similarities of these contexts are highlighted, discussing the application of the CE model suggested. Finally, conclusions are presented in the last section, along with some remarks and recommendations.

Nomenclature

CE	Circular economy
EC	European commission
EEA	Environmental European agency
EU	European union
GNI	Gross national income
MBT	Mechanical biological treatment
MSW	Municipal solid waste
NGO	Non-governmental organizations
PPE	Personal protective equipment
PPP	Public-private-partnership
RDF	Refuse derived fuel
RP	Recycling policies
SC	Selective collection
SDGs	Sustainable development goals
SWM	Solid waste management
WEEE	Waste electrical and electronic equipment

2. Methodology and analysis of the contexts

This study investigates the differences between two contexts where recycling policies (RP) are not still implemented, discussing the application of a theoretical CE model. The international collaboration among the universities involved in this article and a literature survey allow

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