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Improvement actions in waste management systems at the provincial scale based on a life cycle assessment evaluation

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ABSTRACT

This paper reports some of the findings of the 'GERLA' project: GEstione Rifiuti in Lombardia – Analisi del ciclo di vita (Waste management in Lombardia – Life cycle assessment). The project was devoted to support Lombardia Region in the drafting of the new waste management plan by applying a life cycle thinking perspective. The present paper mainly focuses on four Provinces in the Region, which were selected based on their peculiarities. Life cycle assessment (LCA) was adopted as the methodology to assess the current performance of the integrated waste management systems, to discuss strengths and weaknesses of each of them and to design their perspective evolution as of year 2020.

Results show that despite a usual business approach that is beneficial to all the provinces, the introduction of technological and management improvements to the system provides in general additional energy and environmental benefits for all four provinces. The same improvements can be easily extended to the whole Region, leading to increased environmental benefits from the waste management sector, in line with the targets set by the European Union for 2020.

1. Introduction

Life Cycle Assessment (LCA) applied to waste management systems has rapidly expanded over the last few years as a tool able to capture and handle complexities and interdependencies typically characterising modern integrated waste management (WM) systems (Blengini et al., 2012). The LCA methodology has widely been used to evaluate the environmental and energetic performance of real or fictional integrated municipal solid waste (MSW) management systems (e.g., among the most recent, Antonopoulos et al., 2012; Blengini et al., 2012; Rigamonti et al., 2013; Giugliano et al., 2011; Pires et al., 2011; Bovea et al., 2010).

Nevertheless, only a few studies exist about LCA applied at a provincial scale in Italy. Among the most recent ones, Blengini et al. (2012) report the results obtained from the applications of LCA to the integrated MSW management systems of Torino and Cuneo provinces in Northern Italy. Cherubini et al. (2008) applied LCA to the case of MSW management in Rome, whereas De Feo and Malvano (2009) studied the environmental impacts associated with the WM in the district of Avellino, in Southern Italy. Moreover, LCA is not widely used as a decision-supporting tool in Italy (Tarantini et al., 2009). According to Blengini et al. (2012), one of the key issues is understanding what LCA can do for local waste authorities and operators. The authors also claim that it is still unclear to what extent these subjects are aware of the potential of waste management LCAs and/or are willing to put into practice the results.

In contrast to this general trend, Regione Lombardia, which is drafting the new Regional Waste Management Program, has decided to consider the environmental performance as a key evaluation criterion in future planning decisions, with LCA considered the most suitable tool to reach this aim. LCA was thus used in the GERLA project (GEstione Rifiuti in Lombardia: Analisi del ciclo di vita – Waste management in Lombardia: Life cycle assessment) (Rigamonti et al., 2013) for the evaluation of the environmental performance of the current WM system implemented in Lombardia Region and of some perspective scenarios. Lombardia is a 10 million inhabitants' Region of Italy, where about a fifth of Italy's gross domestic product is produced, making it one of the wealthiest regions in the whole of Europe. Besides, the analysis at the regional scale, in the GERLA project a specific focus was devoted to the WM systems implemented in four out of the twelve provinces that make up the Region.

This paper focuses on the LCA applied in the GERLA project at the provincial scale. Milano, Bergamo, Pavia and Mantova are the provinces selected for the analysis. First of all, the existing WM system in each province was evaluated by means of the LCA methodology. Then, the interpretation of the results about the existing WM systems has allowed the definition, carried out together with the planners, of perspective scenarios for the year 2020. These were subsequently evaluated, again with the LCA methodology,

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Table 1
Geographical information, composition of the collection of MSW and total amount of waste collected (rounded figures) for the four selected provinces (reference year: 2009).

	Milano	Mantova	Pavia	Bergamo
Key information				
Inhabitants	3,060,000	420,000	550,000	1,110,000
Population density (inh. per km^2)	2,013	177	185	404
GDP per capita (€)	45,500	30,300	22,100	29,400
Yearly per capita waste production (kg)	470	498	506	381
Waste collection composition[a]				
Aluminium	0.02%	0.07%	0.01%	0.12%
Paper	13%	1%	8%	16%
Wood	3%	3%	2%	4%
Ferrous metals	0.8%	1%	1%	2%
Food waste	11%	5%	1%	12%
Plastics	3%	3%	1%	3%
Green waste	5%	21%	9%	11%
Glass	9%	2%	5%	9%
Multi-material fraction	3%	5%	1%	2%
Residual waste	53%	49%	71%	41%
Total waste (*t*)	1,436,639	208,993	278,582	423,063
Total waste with respect to the regional total (%)	32.6	4.7	6.3	9.6

[a] The entries refer to the different waste flows collected, whether through a mono-material collection (aluminium, paper and wood) or a multi-material one. Residual waste is also included. The source of these data, as well as for the total amount of waste, is O.R.SO. (Osservatorio Rifiuti SOvraregionale – regional waste observatory) database.

Table 2
Products obtained from the treatment of each fraction (i.e. secondary products) and corresponding avoided product (i.e. avoided primary products) assumed in the LCA. Substitution ratio is also reported for the packaging materials.

Fraction	Secondary product	Avoided primary product	Substitution ratio[a]
Ferrous metals	Liquid secondary steel from iron scraps	Liquid primary steel from pig iron	1:1
Aluminium	Secondary aluminium ingots from aluminium scraps	Primary aluminium ingots from bauxite	1:1
Glass	Generic glass container from cullets	Generic glass container from raw materials	1:1
Wood	Particle board from recovered wood	Plywood from virgin wood	1:0.6
Paper	Non-deinked pulp from wastepaper	Virgin thermo-mechanical pulp	1:0.8
Plastics	Granules of recycled PET	Granules of virgin PET	1:0.8
	Granules of recycled HDPE	Granules of virgin HDPE	1:0.8
	Flakes of mix of polyolefins	Wood	1:1
Green waste	Compost	Inorganic fertilisers and peat[b]	–
Food waste (sent to composting)	Compost	Inorganic fertilisers and peat[b]	–
Food waste (sent to anaerobic digestion)	Compost and electricity	Inorganic fertilisers and peat[b], and electricity produced by a combined cycle power plant fed with natural gas	–
Residual waste (sent to landfill or to WTE plant)	Electricity and heat	Electricity produced by a combined cycle power plant fed with natural gas and heat generated by household boilers fed with natural gas	–
RDF (sent to WTE plant)	Electricity and heat	Electricity produced by a combined cycle power plant fed with natural gas and heat generated by household boilers fed with natural gas	–
RDF (sent to cement kiln)	Secondary fuel	Petcoke[c]	–

PET = polyethylene terephthalate; HDPE = high density polyethylene; WTE = Waste-To-Energy; RDF = Refuse Derived Fuel.

[a] It takes into accounts the quality of the secondary products in comparison with that of the corresponding primary product: a substitution ratio 1:1 means that 1 unit of secondary packaging material replaces 1 unit of the corresponding primary material; a substitution ratio 1:<1 means that 1 unit of secondary material replaces less than 1 unit of the corresponding primary material (Rigamonti et al., 2010).

[b] According to current Italian situation, we assumed that 25% of the produced compost is used in garden centres in substitution of peat, 68% in agriculture in substitution of mineral fertilisers with the same content of nutrients and 7% in environmental reclamations without any substitution (Centemero, 2010). The assumed content of nutrients per tonne of compost is 6.2 kg for N, 2 kg for P and 4.5 kg for K (AEA, 2001). 1 m^3 of compost (i.e. 680 kg) substitutes for 1 m^3 of peat (i.e. 300 kg) (Malpei et al., 2008).

[c] The substitution is based on the lower calorific value of RDF and petcoke.

to verify and quantify the improvements associated with the various actions implemented. This has provided Regione Lombardia with useful indications for the drafting of the new Regional Waste Management Program.

The novelty of this research can be summarised as follows: (1) modelling of the WM systems implemented in the four selected Italian provinces with data mainly acquired from direct contacts with the operators of the plants; (2) analysis of the environmental performance associated with the selected provincial WM systems in order to identify the strengths and weaknesses of each of them and (3) identification of feasible improvement actions to be included in the Regional Waste Management Program as recommended future orientation.

2. Goal and scope definition

LCA was applied to evaluate the environmental performance of the WM systems implemented in the four selected provinces: Milano, Bergamo, Pavia and Mantova. The choice was based on