Resources, Conservation and Recycling 97 (2015) 16–23

Contents lists available at ScienceDirect

Resources, Conservation and Recycling

journal homepage: www.elsevier.com/locate/resconrec

Economic and environmental comparison between two scenarios of waste management: MBT vs thermal treatment

D. Panepinto*, G.A. Blengini[1], G. Genon[2]

DIATI, Politecnico di Torino, Corso Duca degli Abruzzi, 24, 10129 Torino, Italy

ARTICLE INFO

Article history:
Received 24 September 2014
Received in revised form 12 January 2015
Accepted 5 February 2015
Available online 27 February 2015

Keywords:
Municipal solid waste management
Thermal treatment
Mechanical biological treatment
Life cycle assessment
Economic evaluation

ABSTRACT

The paper examines, under specific local situation of planning of innovative solutions for municipal solid waste treatment, the results obtained from a technical, economic and environmental comparison between two different scenarios for waste management: the first scenario foresees the gasification of the residual waste after separate collection and the energetic utilization of the produced syngas, while the second one is based on a mechanical separation of the residual waste in three fluxes: a combustible flux to be utilized, after quality improvement, as RDF (residue derived fuel), a wet organic flux to be sent to anaerobic digestion and a residual essentially mineral flux. For both the scenarios different levels of separate collection were considered.

The comparison took into account environmental and economic aspects.

From the environmental point of view, the tool of LCA (life cycle assessment) has been used to address some key environmental aspects and the global acceptance of the two scenarios. As concerns the economic point of view, conventional economic criteria, i.e. investment and operating costs transferred to citizens, have been considered.

For the practical implementation of the scenarios and in order to verify the possibility to adopt them in a specific territorial situation, additional aspects of practical management, reliability and need to individuate synergies with other territorial infrastructures have been considered.

The results of the analysis for this specific case revealed that the MBT (mechanical biological treatment) option is preferable from the environmental point of view, while the pyro-gasification option is better from the economic point of view under the vast majority of operating conditions considered. Different practical implementations problems characterize both the scenarios.

More generally, the comparison methodology that has been defined and used for the scenarios of the considered case can establish a more general useful approach, in order to help the definition of the best solution for waste management planning.

1. Introduction and aim of the work

In order to define the optimal final destination of a required quantity of municipal solid waste (MSW), it is necessary to consider not only the monetary costs of the operations but also the environmental aspects of them. For a given location the availability of waste-processing industrial infrastructures (separation plants, waste-to-energy systems, final landfills or innovative solutions), the cost of constructing them, and their environmental impact must be taken into account [Plata-Díaz et al., 2014].

Actually the preferred options for MSW treatment require waste separation from the collection process, with the goals to reuse materials and to produce recycled products. In necessary connection with the collection and recovery scheme, however, there is a significant flow of undifferentiated waste, to which the rejects from the valorization process for the reuse must be added; suitable solutions must be found for the disposal of this additional flux. For a more comprehensive evaluation it must be taken into account that this flow (normally an high percentage of gross waste production) contains a minor fraction of directly reusable materials (metal, glass, organic material), and on the contrary consists of a mix of a combustible fraction, a residual wet organic fraction and a substantially inert mineral fraction. On the basis of this composition, and bearing in mind the high interest towards the production of

* Corresponding author. Tel.: +39 011 0907632; fax: +39 011 0907699.
E-mail addresses: deborah.panepinto@polito.it (D. Panepinto), gianandrea.blengini@polito.it (G.A. Blengini), giuseppe.genon@polito.it (G. Genon).
[1] Tel.: +39 011 0907715; fax: +39 011 0907699.
[2] Tel.: +39 011 0907660; fax: +39 011 0907699.

http://dx.doi.org/10.1016/j.resconrec.2015.02.002
0921-3449/

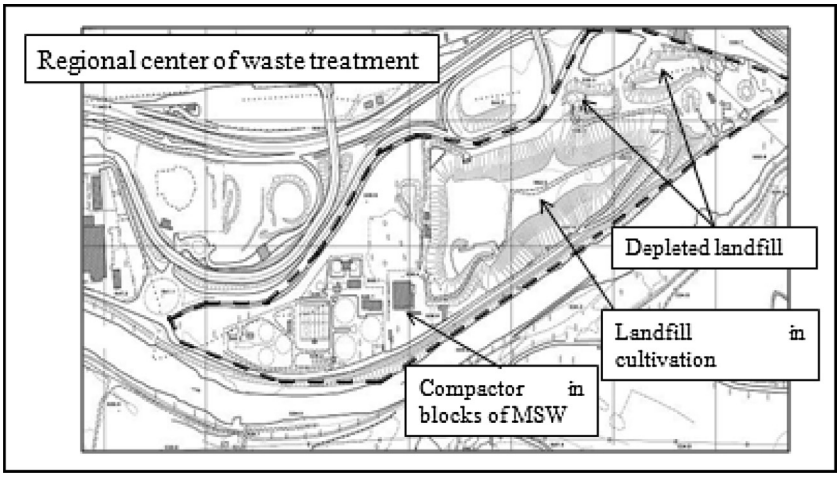

Fig. 1. Scheme of the analyzed area.

electricity and thermal energy in substitution of non-fossil sources, it is worth to underline the double aim of disposal of waste and, at the same time, production of electricity and thermal energy [Panepinto and Genon, 2012].

Two alternatives methods can be proposed for the direct energetic recovery: direct combustion of the undifferentiated flow in incineration plants [Panepinto and Genon, 2014] or innovative system leading to a secondary fuel, as gasification [Arena, 2012; Panepinto and Genon, 2011; Shen et al., 2014; Pinto et al., 2014; Niu et al., 2014]). As an alternative, mechanical separation systems downstream of the selective collection can be used to separate the wastes into three fractions: a fuel fraction (known as RDF, refuse derived fuel, which can be used in specific dedicated plants or introduced into the general fuel market [Sarc and Lorber, 2013]), a wet fraction (for which, with the possibility of biological anaerobic digestion plants, there is also a prospect for additional energy valorization [Wana et al., 2013; Fernández-Rodríguez et al., 2014; Krishna and Kalamdhad, 2014; Ariunbaatar et al., 2014; Lindmark et al., 2014; Bolzonella et al., 2006]), and a mineral fraction (for which there is currently no viable option except their disposal in a landfill).

By analyzing the literature it is possible to verify that the main required tools that are used in order to perform a comparison among these different waste management systems are a comparative environmental compatibility balance, and an industrial economic analysis.

For the first aspect, life cycle assessment (LCA) applied to MSW management has rapidly expanded over the last few years as a tool able to capture and handle complexities and interdependencies typically characterizing modern integrated waste management systems (I-WMS) [Blengini et al., 2012; Blengini, 2008; Laurent et al., 2014].

With reference to the European situation and the most recent legislation published by the European Commission (EC), i.e. the Waste Directive 2008/98/EC (EU, 2008), currently under revision, LCA is used to rationalize technological choices and to define management strategies; in less advanced regions with a similar approach LCA is used to develop measures required to implement more integrated solid waste management systems, and to reach EU directives.

The LCA methodology according to ISO 14040 is worldwide accepted and appreciated because it allows an objective evaluation of the environmental performances of products and processes [Guinée, 2002]. However when applying LCA to waste management, there are some sector specific aspects that must be considered and some assumptions that must be undertaken, as they affect the results to a large extent [Finnveden, 1999; Ekvall et al., 2007]. In order to minimize the negative influence that these assumptions might have in terms of acceptability of the results, a participatory approach, with strict interaction with all the scenarios stakeholders, must be adopted from the early stages of the research [Blengini et al., 2012].

From the point of view of the economic analysis, it is important to highlight that there are several estimation models for solid waste operations that are described in the literature. Most of these models are focused only on strict operational economic aspects [Plata-Díaz et al., 2014], while other studies include also environmental aspects [Sonesson et al., 2000]. As an example, in [White et al., 1995] the environmental impact is a major issue, along with economics.

On the basis of the above described environmental and economic choice criteria, the aim of this work is a comparison between the two different waste management scenarios that have been identified, in particular a first one based on thermal treatment (pyro-gasification) and a second one that considers the option of a mechanical–biological treatment (MBT). Besides the indicated choice criteria, also the technical aspects and the reliability aspects of the identified systems have been considered.

2. Materials and methods

The study area where the MSW management scheme has been implemented can be considered a medium extension area (3200 km^2, 128,000 inhabitants) for the Italian context. The actual organization of the waste management system foresees the transfer of the residual waste after separate collection (corresponding to about 60,000 t/y) to a single treatment centre constituted by a waste block compaction and a final landfill as reported in Fig. 1.

The analyzed area is surrounded by the Alps, including four of the highest mountains in Europe (Monte Bianco, Cervino, Monte Rosa and Gran Paradiso), and it is crossed by the Dora Baltea that it is an important Po river tributary. The conformation of the entire region is a result of the glaciations that excavated the main valley.

The population is concentrated in a principal medium-size town (35,000 inhabitants) and more than 70 small towns of less than 5000 inhabitants. This population is concentrated chiefly (more than 75%) in central zone of the valley, while the remaining is distributed in the higher mountain zones.

The landfill facility currently under cultivation will exhaust within the end of 2014. So it is necessary to find a new waste management solution.