ARTICLE IN PRESS

Waste Management xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

Waste Management

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

Potential SRF generation from a closed landfill in northern Italy

Giorgia Passamani [a], Marco Ragazzi [a], Vincenzo Torretta [b,*]

[a] University of Trento, Department of Civil, Environmental and Mechanical Engineering, via Mesiano 77, I-38123 Trento, Italy
[b] University of Insubria, Department of Biotechnologies and Life Sciences, Via G.B. Vico 46, I-21100 Varese, Italy

ARTICLE INFO

Article history:
Received 13 May 2015
Revised 2 July 2015
Accepted 15 July 2015
Available online xxxx

Keywords:
Landfill mining
Solid recovered fuel
Mechanical biological treatment
Bio-drying

ABSTRACT

The aim of this work is to assess the possibility of producing solid recovered fuel (SRF) and "combustible SRF" from a landfill located in the north of Italy, where the waste is placed in cylindrical wrapped bales. Since the use of landfills for the disposal of municipal solid waste has many technical limitations and is subject to strict regulations and given that landfill post-closure care is very expensive, an interesting solution is to recover the bales that are stored in the landfill. The contents of the bales can then be used for energy recovery after specific treatments.

Currently the landfill is closed and the local municipal council together with an environmental agency are considering constructing a mechanical biological treatment (MBT) plant for SRF production.

The municipal solid waste that is stored in the landfill, the bio-dried material produced by the hypothetically treated waste in a plant for bio-drying, and the SRF obtained after the post-extraction of inert materials, metals and glass from the bio-dried material were characterized according to the quality and classification criteria of regulations in Italy.

The analysis highlighted the need to treat the excavated waste in a bio-drying plant and later to remove the inert waste, metals and glass. Thus in compliance with Italian law, the material has a high enough LHV to be considered as "combustible SRF", (i.e. an SRF with enhanced characteristics).

1. Introduction

European Union legislation (Directive 2008/98/EC) has established a waste hierarchy that prioritizes disposal methods such as incineration or landfilling. This hierarchy of treatment includes prevention, reduction, reuse, recycling and recovery, thus minimizing disposal methods.

The introduction of the Landfill Directive (1999/31/EC) in the EU has also led to significant restrictions in the landfilling of biodegradable material and has also set a limit on the lower heating value (LHV) of the landfilled material (<13 MJ/kg) (Trulli et al., 2013; Bartl, 2014; Rada et al., 2014; Torretta et al., 2014). Once a landfill reaches its capacity, it must be closed but still managed.

A landfill closure includes the installation of a final cover system, a leachate and gas collection system, and a groundwater monitoring system. The problem of controlling and treating leachate (Raboni et al., 2013) is critical, both in terms of the techniques available and the correct location of the landfill (De Feo et al., 2014). With regard to the landfill gas, it is a complex mix of different gases created by the action of microorganisms within a landfill. Landfill gas is approximately forty to sixty percent methane (CH_4), with the remainder being mostly carbon dioxide. In absence of collection and treatment, methane landfills emissions represent both, a potential explosion hazard (Scheutz et al., 2014) and a strong environmental threat because CH_4 is a powerful greenhouse gas. In consequence, assessing landfills potential, as methane producer is important from the point of view of hazard control and the estimate of the eventual methane contribution on the climatic global change in next years (Yochim et al., 2013).

Post-closure care (PCC) includes the operation and maintenance of the final cover system, the leachate and gas collection system, a groundwater monitoring system, surface water management, site access control, deed restrictions, record maintenance, and reporting. Closure and PCC are still relatively expensive and do not ensure that the surrounding environment is taken into account (Laner et al., 2012; Chakma and Mathur, 2013; Beaven et al., 2014). Thus in recent years the focus on landfill reclamation/mining has increased (Krook et al., 2012; Marella and Raga, 2014).

Landfill mining (LFM) involves the excavation, transfer, and processing of buried material taken from an active or closed (generally unlined) landfill (Hogland et al., 2004). The purposes of LFM are: conservation of landfill space; reduction in landfill area; elimination of a potential source of contamination; mitigation of an

* Corresponding author.
E-mail address: vincenzo.torretta@uninsubria.it (V. Torretta).

http://dx.doi.org/10.1016/j.wasman.2015.07.024

Please cite this article in press as: Passamani, G., et al. Potential SRF generation from a closed landfill in northern Italy. Waste Management (2015), http://dx.doi.org/10.1016/j.wasman.2015.07.024

existing contamination source; energy recovery; recycling of recovered materials; reduction in management costs, and site redevelopment.

LFM is generally a six-step process: (1) exploration, (2) aerobic stabilization (not always included), (3) mining and transport, (4) conditioning, (5) specific treatment of material, (6) recycling resources/residue disposal (Diener et al., 2013). Fig. 1 shows a theoretical example of mining and waste processing in a sustainable landfill.

Landfills that are made up of municipal solid waste (MSW) bales for energy plants can be more easily recovered (Ozbay and Durmusoglu, 2013).

Baling technology is a promising temporary storage method for MSW, which is being exploited in several parts of the world in order to prevent, for example, unpleasant smells, leachate formation, hazardous landfill gases, explosions, and fire risks (Nammari et al., 2007). As the use of baling technology in solid waste management is quite new, there is a limited literature available on the performance of the baled solid waste (Baldasano et al., 2003). The studies on this technology also deal mostly with safety aspects or environmental issues, such as fire and explosion hazards, and emission protection (Nammari et al., 2004, 2007; Wagner and Bilitewski, 2009). However, the greatest benefits of this technology are the generation of lower quantities of methane and reduction in leachate problems. MSW bales can therefore be stored safely, representing a promising method of interim MSW storage (Hogland and Marques, 2003; Ozbay and Durmusoglu, 2012; Wagner and Bilitewski, 2009).

Although baling technology was originally developed as a temporary solution for waste storage due to technical problems in current disposal facilities or in the case of high seasonal peaks in waste production, it has also been used for the long-term storage of MSW for thermal use (Stenis et al., 2011; Tsagas et al., 2009; Wagner and Bilitewski, 2009).

The MSW from bales after various pre-treatments can be used for the production of a solid recovered fuel (SRF) that can be used for energy purposes.

The SRF can be obtained through mechanical–biological (MBT) processes with single (bio-drying and post-processing) or double streams (sieving and treatment of the oversieve). MBTs cover a range of waste treatment technologies which, when combined, can be used to treat MSW. MBT is defined as a process that "partially processes mixed household waste by mechanically removing some parts of the waste and biologically treating others, so that the residual fraction is smaller and more suitable for a number of possible uses" (Abeliotis et al., 2012). The complexity of the mechanical treatment determines the degree of sophistication of the MBT. The biological treatment of waste converts the organic material into a more stable form. It consists of either an aerobic or an anaerobic process that uses microorganisms with or without oxygen.

Bio-drying is an MBT approach that exploits the biological reactivity of the waste in order to produce a material with an improved lower heating value thanks to the reduction in moisture. Either with or without some post-treatment, this material can be considered as an SRF, which can be used for energy production in industrial plants.

In the EU, the classification of fuels from MSW has changed in recent years with the introduction of 30 technical documents, mainly in the range of norms UNI CEN/TS 15357-15747, some of which have been operative since 2006. These documents set out all the characteristics, sampling methods, definitions, parameters of interest, and analytical methods for solid recovered fuel (Rada and Andreottola, 2012). According to EN 15359, the SRF classification system is based on several indicators such as economic, operational and environmental ones.

The classification for SRFs in Italy (Decree 205/2010) is based on limit values for three important fuel properties: lower heating value (LHV), chlorine, and mercury content (Rada and

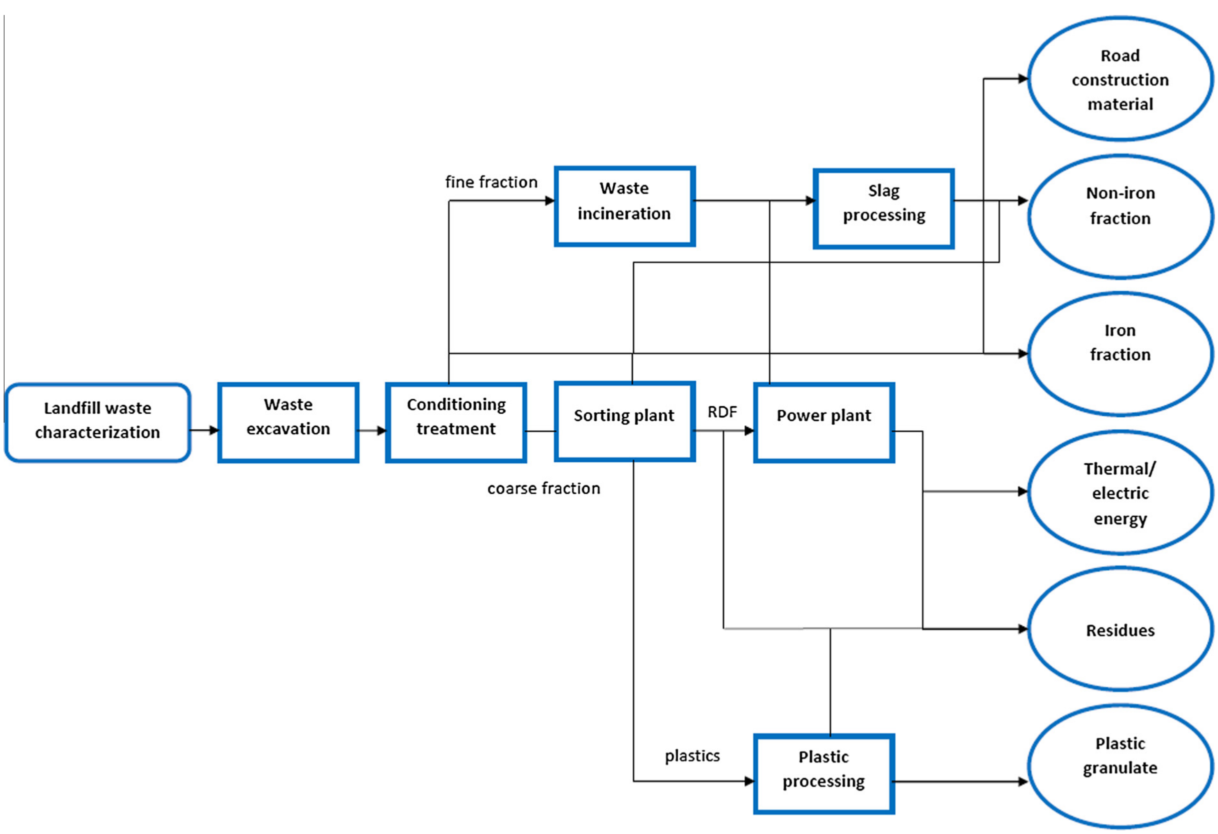

Fig. 1. Example of landfill mining and waste processing (Diener et al., 2013).