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# Characterization of landfilled materials: screening of the enhanced landfill mining potential

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ABSTRACT

The main objective of "Enhanced landfill mining" is the valorization of the excavated waste materials that have been stored in the landfill. Previous landfill mining projects have shown that each landfill site has its own potential with regard to landfill mining. Factors such as the age of the landfill, type of landfill and the country or region where the landfill is located might have an impact on the type of materials stored in the landfill and their valorization potential. In the present article, the valorization options for the materials stored at the REMO site in Houthalen (Belgium) are assessed based on excavation tests done at locations containing either municipal solid waste (MSW) or industrial waste (IW). The results reveal differences in the composition and the characteristics of the waste materials with regard to type of waste (MSW versus IW) and the period during which the waste was stored. Based on the characteristics of the different fractions, an initial assessment was made with regard to their valorization potential. For the plastics, paper/cardboard, wood and textile recovered in this study, waste-to-energy is the most suitable valorization route since the level of contamination was too high to allow high quality material recycling. For metals, glass/ceramics, stones and other inerts in the waste, material valorization might be possible when the materials can adequately be separated. The amount of combustible in the excavated waste varied between 23 and 50% (w/w) with a calorific value of around 18 MJ kg$^{-1}$ dw and confirm the large potential of waste-to-energy for landfill mining. All waste samples recovered from the landfill contained a large amount (40–60% (w/w)) of a fine grained (<10 mm) mainly mineral waste material. Especially for industrial waste (mainly shredder from ELV), the fines contained high concentrations of heavy metals (Cu, Cr, Ni and Zn) and offer opportunities for metal extraction and recovery. The development of a treatment plant that enables maximum resource recovery remains however one of the technological challenges for further development of enhanced landfill mining.



## 1. Introduction

In the last decade new technologies and processes have emerged that enable more efficient recycling of materials from often complex and heterogeneous waste streams (Simonds, 1999; Archer et al., 2005; Cossu and Gadia, 2007). The principal drivers for these developments are the local and EU legislation on waste (Directive 2008/98/EC), as well as the growing demand for metals, high quality recycled aggregates and waste derived fuels. Both the legislative framework and increasing market prices for the recycled materials create conditions that justify the development of new waste recycling and separation technologies (Archer et al., 2005; Forton et al., 2006; Tachwali et al., 2007).

Recently, the concept of Enhanced Landfill Mining (ELFM) has been proposed as an improved practice of landfill mining. Essentially, ELFM includes the combined and integrated valorization of (historic and future) waste streams as both materials (Waste-to-Material, WtM) and energy (Waste-to-Energy, WtE), while respecting stringent ecological and social criteria (Jones et al., accepted for publication). One of the main drivers of "Enhanced landfill mining" (ELFM) is the valorization of waste materials excavated from landfills. Due to the heterogeneous nature of the

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waste streams in landfills, separation and treatment of the different waste streams are required to enable the generation of valuable (recycled) materials. Specific treatment and separation schemes are available for the treatment of various specific (often) heterogeneous waste streams such as shredder residue, bottom ash, C&D waste and contaminated soil. Most of these schemes make use of a combination of dry and/or wet mechanical separation techniques including crushing, milling, sieving, magnetic and eddy current separation of ferrous and non-ferrous metals, density separation based on air flow, water based density separation techniques, jigging, etc… In case of ELFM, the treatment plant should be able to recover high quality waste fuel and materials (e.g., ferro and non-ferro metals) from a mixture of heterogeneous waste streams of which the composition and hence the physical and chemical properties are influenced by the age of the waste and the degradation of the waste over time. Part of the waste streams are even residues from mixtures of the residual waste originating from elaborated treatment schemes that were designed in the past to recover and recycle materials from specific waste streams. The development of a separation plant that enables maximum resource recovery is one of the technological challenges of enhanced landfill mining.

Previous pilot and pre-feasibility studies around the world as well as completed landfill mining projects have shown that different landfill sites have different potential with regard to landfill mining. Factors such as the age of the landfill, type of landfill, meteorological, hydrological conditions and the country or region where the landfill is located might have an impact on the type of materials stored in the landfill and their valorization potential. To determine the recycling potential for a specific landfill, quantitative and qualitative analysis of the waste streams stored are essential (Prechthai et al., 2008).

The Closing the Circle project (CtC) in Houthalen-Helchteren (Belgium) is the first ELFM case study. The feasibility of the CtC/ELFM was investigated through several studies and analysis. The impact on biodiversity and recovery of natural land is described by De Vocht and Descamps (2011). The economic feasibility of ELFM was explored and special attention was given to the environmental impact through the calculation of the carbon footprint (Van Passel et al., accepted for publication). Although it is clear that all these aspects are important, the feasibility of ELFM will also be determined by the quality of the materials retained in the landfill and the WtM and WtE technologies available for valorization. Therefore, this paper focuses on the characteristics and the valorization potential of the waste streams stored at the REMO site in Houthalen-Helchteren (Belgium) obtained during an exploratory field test (EFRO-project 475, 2010–2011). At the REMO site around 15 million tons of waste have been landfilled since the beginning of the 1970s. Both household and industrial wastes have been landfilled. Records are available specifying the amount, the type and the location of the different waste streams within the landfill. Since the records provide no detailed information with regard to the physicochemical properties of the waste necessary to assess the valorization potential, an exploratory field test was carried out at the REMO site. The objectives of the field test were to:

- Evaluate differences in composition of the waste with regard to the type of waste stored (household versus industrial waste);
- Assess the variation in composition for each specific waste type;
- Investigate the impact of storage time on the composition and characteristics of the waste;
- Compare the composition of the waste with data available in the records and in literature;
- Make an assessment of the valorization potential of the materials stored in the landfill.

## 2. Materials and methods

### 2.1. Site description

The REMO landfill has been in operation since the start of the 1970s and is located in Houthalen-Helchteren in the province of Limburg in Belgium. The total area of the landfill containing non-hazardous waste that is considered for enhanced landfill mining is about 1.286.200 $m^2$. The landfill has been divided into sections based on the type of waste stored, the period during which the section was in operation and the location in the landfill. For each section information is available with regard to the type and amount of waste stored. Roughly half of the 16.5 million tons that have been landfilled at REMO is household waste. The other half comprises industrial waste such as shredder material from the ELV recycling, metallurgical slags, pyrite containing slags, dried sludge, etc… Leachate collection and treatment, soil protection measurements and methane recovery are in place and comply with the Flemish and European legislation (VLAREM, landfill Directive/1999/31/EC).

### 2.2. Excavation and sampling procedure

An important aspect of the field test was the design of the sampling procedure. Several sampling methods were considered, however, due to the high costs related to the excavation and analysis of the samples a more practical approach was followed taking into account the information available with regard to the different sections in the landfill. It was therefore decided to test 6 different locations in detail during the field test. An overview of the type of waste and the time of disposal at a specific location is given in Table 1. The selection of the test locations was based on the type of waste and the period during which the waste was stored. For municipal solid waste (MSW), the aim was to select 4 locations that varied with regard to the period during which the waste was generated. The

**Table 1**
Description of the waste samples taken at the selected sampling locationsof the field test.

| Number | Year of storage | Type of waste | Top liner | Bottom liner | Description of waste | Depth of landfill (m) |
|---|---|---|---|---|---|---|
| 1 | 1980–1985 | MSW | 1 m clay + 1 m soil | Clay | Municipal solid waste originating from both households, businesses and industrial companies | 11 |
| 2 | 1985–1990 | MSW | 1 m clay + 1 m soil | Clay + 2 mm foil | Municipal solid waste originating from businesses and industrial companies | 13 |
| 3 | 1990–1995 | MSW | 1 m clay + 1 m soil | Clay + 2.5 mm foil | Municipal solid waste originating from businesses and industrial companies | 11 |
| 4 | 1995–2000 | IW | 1 m clay + 1 m soil | Clay + 2.5 mm foil | Industrial waste rich in shredder and fine residues such as sludge | 9 |
| 5 | 1985–1990 | IW | 1 m clay + 1 m soil | Clay + 2 mm foil | Industrial waste | 8 |
| 6 | 1995–2000 | MSW | 1 m clay + 1 m soil | Clay + 2.5 mm foil | Municipal solid waste originating from businesses and industrial companies | 13 |