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INNOVATIVE LANDFILL CHARACTERIZATION: THE CASE STUDY OF ONOZ LANDFILL (WALLONIA, BELGIUM)

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ABSTRACT: Landfill mining projects open new perspectives in terms of waste management, material and land recovery, reduction of environmental risks, among others. Even if the social and environmental benefits of landfill mining projects have been proved, stakeholders are often reluctant to launch landfill mining projects due to the profitability risks. To assess the economic potential of landfill and encourage landfill mining initiatives, RAWFILL has developed a new methodology to characterize the landfill content. This methodology is based on the coupling of geophysical investigations and guided waste samples. By comparison with traditional characterization methods, RAWFILL offers a cheaper and faster way to analyze the landfill content and to elaborate a detailed 3D mapping of the landfill. In this paper, we present the first results of RAWFILL innovative characterization method for the Onoz landfill (Walloon region, Belgium). We also discuss the economic potential of the Onoz landfill mining project as well as the drivers for conducting a profitable landfill mining project. The mining of the Onoz site is supported by the local authorities and the Walloon government. For this reason, the first Green Deal in Wallonia has been signed. This Green Deal will serve as leverage for the implementation of landfill mining projects in Wallonia.

Keywords: Landfill mining, Green Deal , geophysics, RAWFILL, landfill characterization, waste content

1. INTRODUCTION

In Northwestern Europe, more than 100,000 landfills have been inventoried and mapped. According to EURELCO (https://eurelco.org/), 90% of those landfills are unsanitary landfills which were created before the 1999 EU Landfill Directive. Due to the lack of environmental protection systems, they can lead to local pollution, land-use restrictions and even global impacts. Landfill mining (LFM) offers a more sustainable management to reduce environmental risks related to these landfills. Moreover, the benefits of LFM project are multiple: recovery of materials (e.g., metal, plastic, organic wastes) and land, development of new economical projects and infrastructure constructions, improvement of human health, among others.

To encourage and support landfill mining initiatives in NW Europe, the RAWFILL project (Acronym for “Supporting a new circular economy for RAW materials recovered from landFILLs”) was part funded by Interreg NWE program. This project gathers partners and associated partners from Wallonia, Flanders, France, Germany and the United Kingdom.

The main obstacle for stakeholders to start a landfill mining project is the profitability risk due to the lack of reliable data on the recovery potential. Indeed, the relevant data on the economic potential of landfills (e.g., volume, quality and value of materials) is lacking, making their inventories inadequate. Moreover, traditional landfill exploration methods are slow and expensive as they require analysis of multiple excavated waste samples. In a few cases, historical documents can help to identify the content of the waste deposits. However, they are often imprecise or contain erroneous information.

To assess the economic potential of a landfill, an innovative landfill characterization methodology was developed, in the framework of the RAWFILL project, by combining waste sampling and geophysical investigations. Coupling the geophysical investigations with boreholes and trenches data provides a 3D mapping of the landfill allowing us (i) to estimate the extension and boundaries of the waste deposits; (ii) to define the volume of waste and to characterize them; (iii) to detect possible contaminated areas outside the physical limits of the landfill. By comparison with the traditional method, the RAWFILL characterization method provides a relatively cheap, fast and high-resolution way to image the landfill content. It is currently being tested on seven landfill pilot sites across the Northwestern Europe. In this paper, we only present the first results of the Onoz site.

2. THE ONOZ SITE

2.1 Geological and Geographical Settings

The study site (50°29’23’’ N, 4°40’12’’ E; Fig. 1) is located in Onoz (province of Namur, Walloon Region, Belgium).

The Onoz landfill has a surface area of 58,000 m^3. Based on its topography, the landfill is divided into two separated areas: a lower western part and an eastern upper part, separated by a steep slope. Regarding the Walloon sector plan, 65 % of the site is classified as Natura 2000 whereas the rest (35 %) is zoned for economic use. The Onoz landfill has an important ecological interest due to the presence of calcareous grassland and its related fauna and flora. Moreover, the rock walls constitute a natural habitat for rare species such as eagle owls.

The geology of the study site consists of carboniferous massive limestone and dolomite, intercalated with argillaceous limestone belonging to the Onoz Formation (Delcambre & Pinot, 2003). The Onoz landfill is situated in a groundwater protection area. In the lower part of the site, the groundwater table is located a few meters below the subsurface.

2.2 Site History

The Onoz landfill is a former limestone quarry and lime oven. Its activities started in 1902 and stopped in 1966. From 1967 to 1987, the old quarry was used as landfill where household, inert and industrial wastes were dumped, filling the pit. The total volume of the heterogenous waste material deposited was initially estimated at ~185,000 m^3. Since 1995, the site has been studied and monitored by SPAQuE. In 2004, SPAQuE removed 750 tons of tyre deposits that were present at the surface. Except for some wild dumping, there is no more landfill activity in Onoz.

3. RAWFILL – AN INNOVATIVE NEW METHODOLOGY FOR LANDFILLS INVESTIGATION – oriented to evaluate the Landfill mining potential

3.1 Geophysical investigations

A series of geophysical investigations, involving electromagnetic induction (EMI), electrical resistivity tomography (ERT), induced polarization (IP), magnetometry (MAG) and different seismic methods (refraction, surface waves, and ambient noise) were conducted during fieldwork campaigns in 2018 and 2019 (Fig. 1). Combining multiple geophysical methods reduces ambiguities inherent to each method (Dumont et al., 2017; Hellman et al., 2017; Soupios et al., 2017). Such a multi-geophysical approach was applied to the Onoz landfill with the aim of obtaining a three-dimensional representation of the waste body. First, geophysical mapping tools (EMI and MAG) were used to provide information about the lateral extent of the anthropogenic deposits and identify different waste facies. Once done, profiling methods (ERT/IP and seismic methods) were applied in zones of interest revealed by mapping to obtain further vertical information about the waste extent and composition. Seismic methods, which are sensitive to mechanical properties of the subsoil, were mainly used to study the geometry of the landfill and its internal structure. Electrical resistivity tomography and induced polarization, sensitive to electrical properties of the subsoil, were used to indicate the bedrock condition, the type of waste deposits, etc.

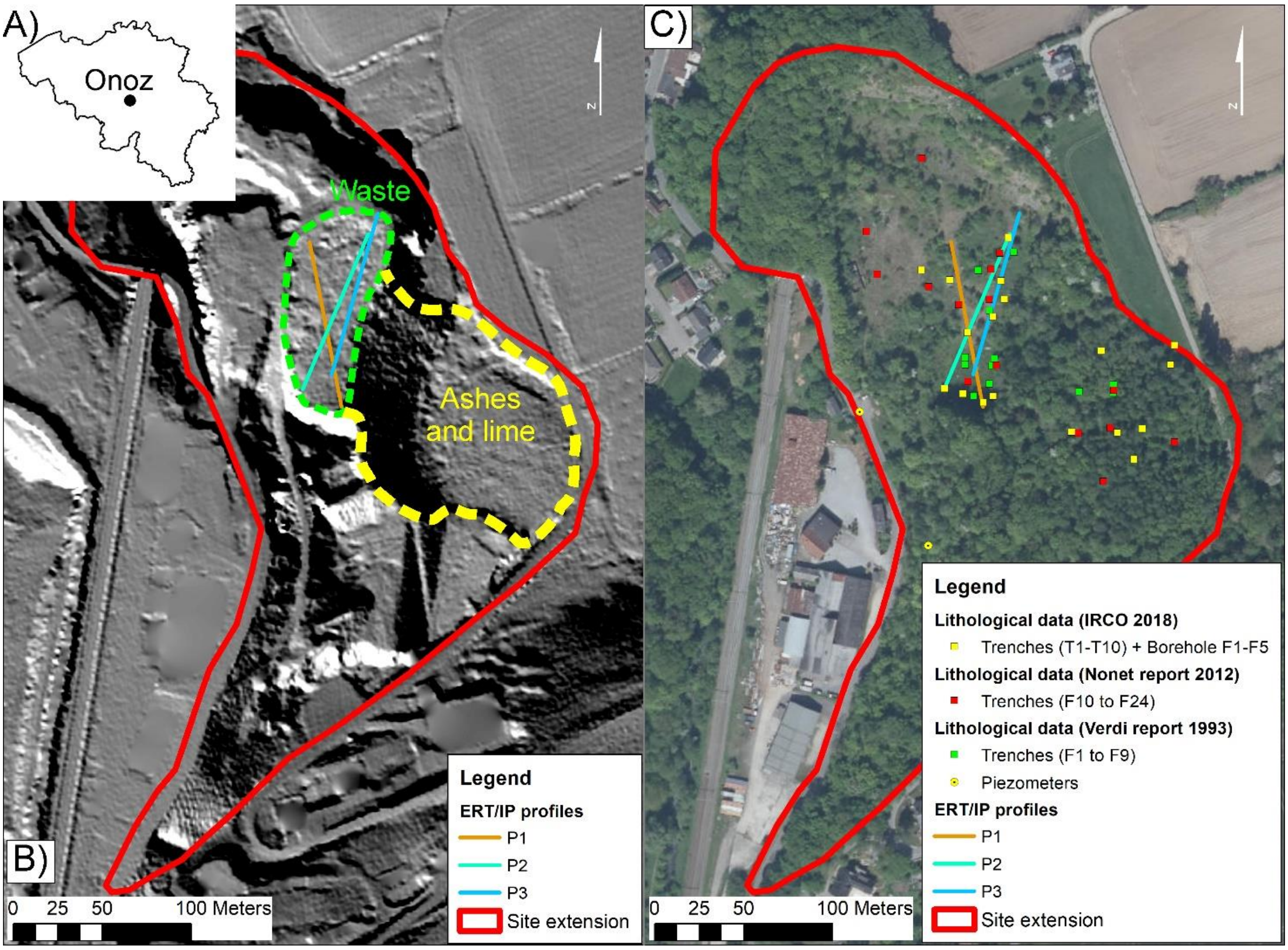

Figure 1. The Onoz Landfill. A) Location of the site; B) Hillshade view of the site (based on lidar data) with the main deposit areas; C) Aerial view of the site in 2018 with sampling locations and ERT/IP profiles.

3.2 Waste sample

Between 1993 and 2018, 34 trenches and boreholes were made to characterize the waste deposits, providing information on the nature of the geological background, volume of waste and contamination levels of the soil (Fig. 1). Moreover, boreholes can give additional information on the part of the landfill where the maximum depth penetration and/or the vertical resolution of the geophysical measurements is reached. The waste description is combined with geophysical data in order to identify the geophysical signatures of each type of waste. Based on their geophysical signatures, we can estimate the content of the landfill and extrapolate the volume of selected waste within the landfill. In comparison with traditional characterization methods, this new methodology considerably reduces the cost and the duration of the characterization study (by at least 30%). Moreover, the RAWFILL methods provide a 3D resource distribution model of the landfill.

4. RESULTS AND DISCUSSION

4.1. Landfill characterization

The geophysical mapping, and particularly the EMI results in the upper eastern part of the landfill, clearly delineated the lateral extension of the lime and ash deposits which are characterized by very high electrical conductivity (> 40 mS/m) or equivalent very low electrical resistivity (<25 Ohm.m), see Fig. 2. The distribution of the ashes and lime is very well constrained due to high contrast with the surroundinglimestone bedrock characterized by much higher electrical resistivity. Unfortunately, the configuration of the site in the upper part of the landfill did not allow the deployement of geophysical methods to estimate the thickness of these deposits. The latter was determined afterwards by drilling revealing up to 25 m of ashes and lime in places. The preliminary results indicate that the initial estimated volume of these deposits (i.e. ~185,000 m^3) was underestimated. The volume of ashes and limes are currently estimated at ~160,000 m^3 and ~48,000 m^3, respectively.

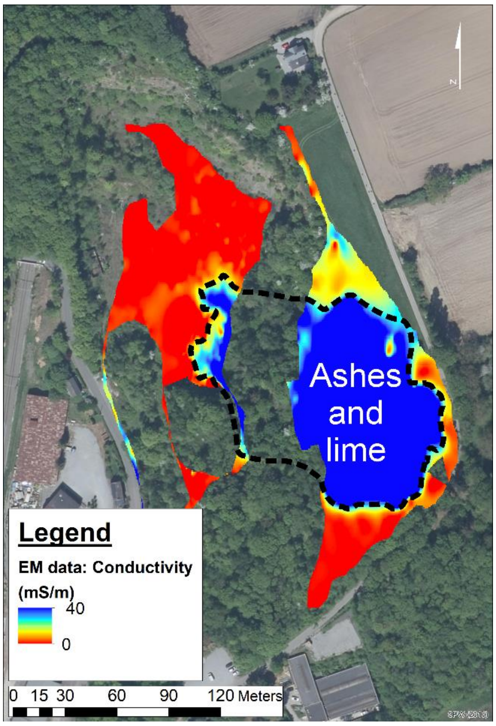

Figure 2. Electrical conductivity map obtained with the EMI method at an investigation depth of 6 m. Lime and ashes are clearly visible because of their contrasted electrical signature compared to the hosting material (i.e. limestone).

In the lower part of the landfill, ERT/IP results allowed the detection of the lime and the ash deposits below a layer of ~3 to 6 m of heterogenous waste deposits (e.g., industrial waste, wastes from the construction sector, car parts, rubber, among others). They also allowed the detection of the bedrock, even though in the lower southern part of the landfill, uncertainties remain concerning its depth due to the heterogeneous waste infill and inherent loss of resolution of the methods with depth (Caterina et al., 2013).

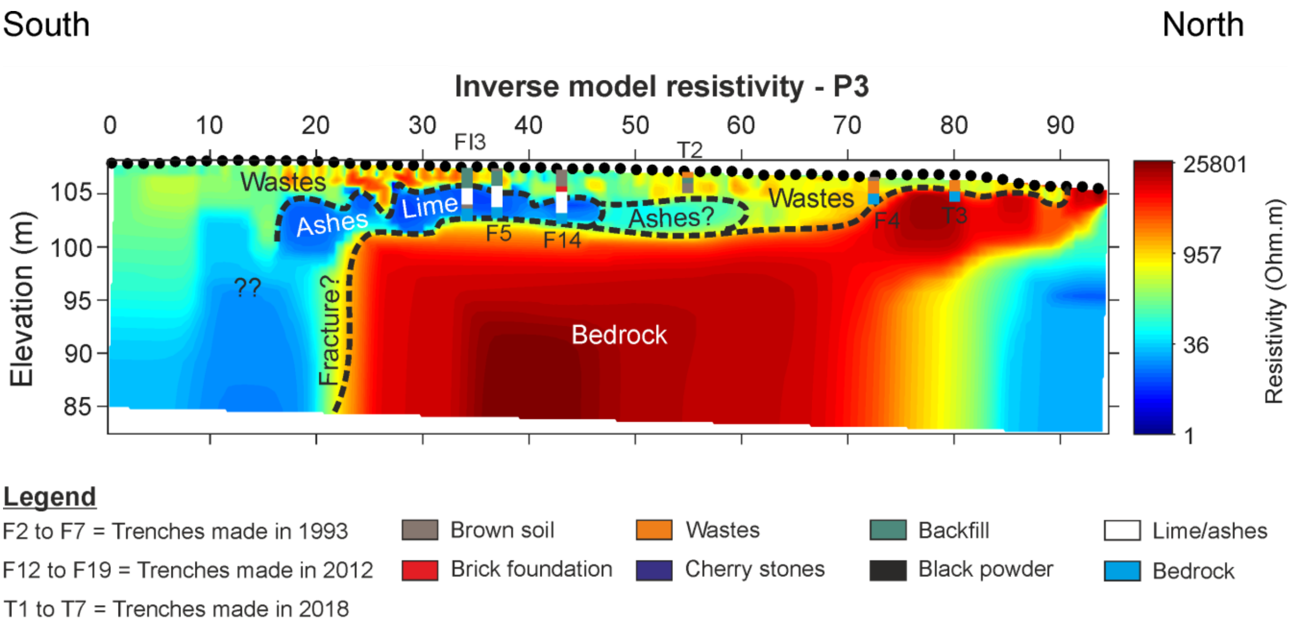

Figure 3. Example of ERT model obtained in profile P3 (see location in Fig. 1). The limestone bedrock is characterized by very high electrical resistivity (>1000 Ohm.m) and is clearly detected in a large portion of the profile. However, in its southern part, a vertical discontinuity is detected leading to a much lower resistivity. Such discontinuity may indicate the presence of a fractured zone in the bedrock containing more water or a former lower exploitation level. Above the bedrock, low resistive zones are attributed to lime and ashes. More heterogeneity in the electrical resistivity is observed closer to the soil surface and is representative of the heterogeneity of waste found. Globally, drilling and trenching are in good agreement with the geophysical interpretation.

New geophysical processing and investigations (involving mainly seismic methods) will be conducted to improve the mapping resolution and its accuracy. Additional boreholes will be sink to better characterize the lower part of the infill and to better constrain the depth and the geometry of the limestone bedrock. The first 3D resource distribution model of the landfill is ongoing and will be available by the end of the year.

4.2 Assessment of the economic potential of the Onoz landfill

The assessment of the economic potential of a landfill relies not only on the type and volume of waste deposits that can be recovered and reintegrated in the economy. The resources of landfills are also considered in a broader perspective, involving environmental aspects, human and health risks, opportunities for the development of new economic projects, urban pressure, visual aspects, energy, land and nature conservation, among others. In the case of the Onoz landfill, the landfill mining driver is not the value of the land or the urban pressure. The economic potential of the Onoz landfill is related to the presence of a relatively thick lime deposit, the biological interests of the site and the possibility to refill decontaminated soil after the mining operations. Regarding waste valorization, the ashes will be valorized in biomass power stations whereas the lime will be used for building purposes. The heterogenous wastes present in the lower part of the site will be sorted and recycled or used for energy recovery from waste incineration.

As the resource recovery and the necessity to rehabilitate the site has been positively evaluated, the following step is the excavation of the Onoz landfill and the recovery of value resources (mainly lime and ashes). The duration of the excavation and site rehabilitation is estimated at around 10 years. After the landfill mining, the site will be rehabilitated for (i) the implementation of new economic activities and (ii) the nature conservation in the Natura 2000 area.

4.3 The Green Deal and the Walloon legislation

The current main issue is that there is no legislation adapted for landfill mining projects in Wallonia (Belgium). Therefore, we had to use either the waste legislation or the soil-contaminated legislation. To solve this legal issue, a Green Deal was signed between the Walloon government and public and private partners. In addition, a working group was created. The Onoz site and its landfill mining project is the first Green Deal that was signed in Wallonia. The Walloon Green Deal is inspired by the Dutch 'Green Deal '. By signing this Green Deal , the Walloon authorities agree to do what is within their capabilities to realize the project. The covenant will clear the way and will provide an acceleration or will serve as leverage for other landfill mining projects in Wallonia.

The working group is composed of the administration, the owner of the site, soil and waste experts, the local administrative authorities where the site is located, SPAQuE and the Ministry of the Environment. The main goal of the working group is to find the best way to implement the landfill mining project in Onoz, by taking into account all the regional regulations. The site is subject to a series of complex regulations due to its location in groundwater-protected zone and its biological interest (Natura 2000 area).

5. CONCLUSIONS

The RAWFILL methodology is currently being tested on seven sites and is already giving promising results. The coupling between the geophysical data and the selected waste samples provides detailed information about the landfill content allowing us to assess the economic potential of the waste deposits. In the case of the Onoz landfill, the recovery of the material and the high ecological interest of the site are the main drivers to conduct a landfill mining project as there is no urban pressure in the area. The main current issue before starting the landfill mining project is the absence of legislation adapted for landfill mining project in Wallonia. To solve this issue, the first Walloon Green Deal was signed and a working group was created. The expected duration of the site excavation and rehabilitation is estimated at ~10 years.

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