LANDFILL MINING AUSTRIA – PILOT REGION STYRIA

T. Wolfsberger *[a], D. Höllen [a], R. Sarc [a], R. Pomberger [a], A. Budischowsky [b], W. Himmel [c], J. Mitterwallner [c]

[a] Montanuniversität Leoben, Chair of Waste Processing Technology and Waste Management, Franz-Josef-Straße 18, 8700 Leoben, Austria, e-mail: avaw@unileoben.ac.at
[b] NUA-Abfallwirtschafts GmbH, Wr. Neustädterstraße 141-143, 2514 Traiskirchen, Austria
[c] Land Steiermark Fachabteilung A14, Bürgergasse 5a, 8010 Graz Austria

** Corresponding Author: tanja.wolfsberger@unileoben.ac.at*

Abstract

Landfilling has long been considered as the best and cheapest way for disposal of waste materials. As waste may contain a variety of contaminants and biological and chemical conversion processes take place in landfill sites, however, old deposits constitute risks to the environment and human health. Furthermore, due to the lack of certain raw materials, new resources must be found for the economy. One possibility to minimize the risk and gain potential secondary raw materials represents landfill deconstruction, where deposited materials are removed and fed to different treatment facilities for energy or material recovery. Only the non-recyclable fraction has to be landfilled again. Hence, the Chair of Waste Processing Technology and Waste Management initiated a fundamental research project in Austria, called “Landfill Mining Austria – Pilot region Styria”, in cooperation with different partners including the government of Styria. This project shall provide fundamental insights into the technology and economics of landfill mining which might be used for large-scale landfill deconstruction in the future. To evaluate the potential of Styrian mass-waste landfills as possible objects for dismantling, the theoretical resource potential of ten selected sites was investigated at first. The results show that about 4,379,330 tons of original substance (OS) of reusable waste materials can be expected. Out of this, approximately 849,110 tons consist of paper, paperboard and cardboard (PPC), 421,720 tons of glass, 514,720 tons of plastics, 265,480 tons of metal-containing waste materials (MCWM), 1,429,500 tons of minerals, 561,760 tons of textiles and personal care products, 41,190 tons of wood, leather and rubber and 295,850 tons of composite materials. Further investigations regarding the quality of the deposited waste materials will be carried out in the future.

Keywords: Landfill Mining, secondary raw materials, resource potential, recovery, landfill deconstruction, Styrian landfill.

Introduction and Definition

Due to the demand for secondary raw materials (e.g. plastics) as possible substitution for fossil fuels (such as oil, carbon and gas), the rising prices and the existing lack of certain raw materials (e.g. metals), new resources must be found for the economy. Hence, in addition to “Mining”, which describes the classical mining as exploration, extraction and treatment of mineral resources, the impact of “Urban Mining” becomes more important. “Urban Mining” comprises all projects, which use anthropogenically created deposits, especially urban settlements, as raw material mines. One branch of Urban Mining is the so-called Landfill Mining, in which deposited wastes are dug out from old landfill sites in accordance with the legal requirements regarding labour safety and neighbourhood protection. Whilst the aim of contaminated site remediation or securing is the reduction of the hazard and pollution potential, waste materials in the course of a landfill mining project are dug out, sorted and

treated to obtain a high amount of excavated waste which can be used for material or energy recovery. Only the non-recyclable waste (usually the fine fraction) is re-installed in a compressed landfill, which means that a much smaller volume of the originally occupied space is claimed. [1] A number of landfill mining projects have already been implemented in the past, the first one 1953 in Israel [2] for the extraction of soil improvers. Motivations for the realization of previous projects were generally the production of compost or soil, the reclamation of landfill capacity, rehabilitation of contaminated sites or groundwater protection [3, 4, 5]. Due to the change of waste management towards resource management, the importance of recovery of secondary raw materials from waste, such as iron and non-ferrous metals, plastics, paper or wood, rises. With using secondary raw materials instead of primary raw materials, emissions to environment and costs can be reduced or prevented.

Challenges of Landfill Mining

To gain a high amount of reusable materials, the considered location for a landfill mining project has to be analysed and prospected accurately. However, these investigations are mostly based on historical data (e.g. administration files, old business permissions and registrations and registers or newspapers) or waste composition (sorting analysis). To obtain reliable information about the real composition of the landfill body, drilling, test pitting and sorting of the excavated materials are necessary. These field methods are costly, time-consuming and complex in their application and describe just a small part of the materials stored in the landfill, but, due to the high heterogeneity of the waste body, no valid statements can be made for the entire landfill [6]. As the amount of reusable materials has a large influence on the economic feasibility of a landfill mining project, new possibilities which allow an estimation of the resource potential and the associated costs in advance have to be found.
Furthermore, in case of an excavation, all relevant and valid legal regulations must be observed. However, there exists no law in Austria which governs either the procedure or the implementation of an old landfills deconstruction explicitly. Therefore, to ensure a safe and law-complying execution of a landfill mining project, new paragraphs, guidelines and recommendations have to be integrated in the Austrian legislation.
Another challenge of landfill deconstruction for the existing sorting technologies is the modest quality of the secondary raw materials recovered from a landfill body. As the waste materials usually are contaminated, due to the long lasting storage within the landfill, they have to undergo a variety of different treatment steps before fed into a recycling process.

Landfill Mining Austria – Pilot region Styria

As a result of the challenges of landfill deconstruction mentioned above (concerning the economic and ecological feasibility), the project “Landfill Mining Austria – Pilot region Styria” was initialized by the Chair of Waste Processing Technologies and Waste Management in cooperation with different partners and the government of Styria. This project shall provide fundamental insights into the technology and economics of landfill mining which might be used for large-scale landfill deconstruction in the future.
In the course of the project, the basic concept for an ecological and legal evaluation of a landfill mining scheme should be elaborated to deviate suitable assessment tools and to develop an economic model for decision making. In summary, the project has identified the following goals:

- Obtain data on the amount, the type and composition of wastes deposited in landfills of Styria.
- Investigation and presentation of the resource potential of selected landfills.

- Define one or more location/s, which may be suitable for a deconstruction.
- Collect data on existing and proven technologies and examine their suitability for landfill dismantling.
- Extraction of representative samples and characterization of the deposited materials in terms of quantity and quality.
- Determination of the actual waste composition and its influence on sorting technologies.
- Representation of the real usable content and evaluation of the amount and quality of recovered materials.
- Development of economically viable recovery paths and markets, recruiting of potential customers.
- Use results of the studies for introduction of new legislation in Austria to facilitate the use of old landfills as secondary raw material storages in future.

Depending on the results obtained, landfill deconstruction concepts and projects, treatment, sorting and recycling technologies, processes for the secondary raw materials industries, normative and legal requirements (regulations, directives and laws) and business models for landfill operators should be derived. The implementation of the project will be realized in the form of a three-stage process (fundamental analysis, real data analysis and evaluation), which can be seen in Figure 1. Due to the geological and environmental conditions as well as waste management options (variety of different mechanical-biological plants, incinerators and landfill technologies) the region of Styria offers many advantages, which are required for the implementation of the project described in this paper.

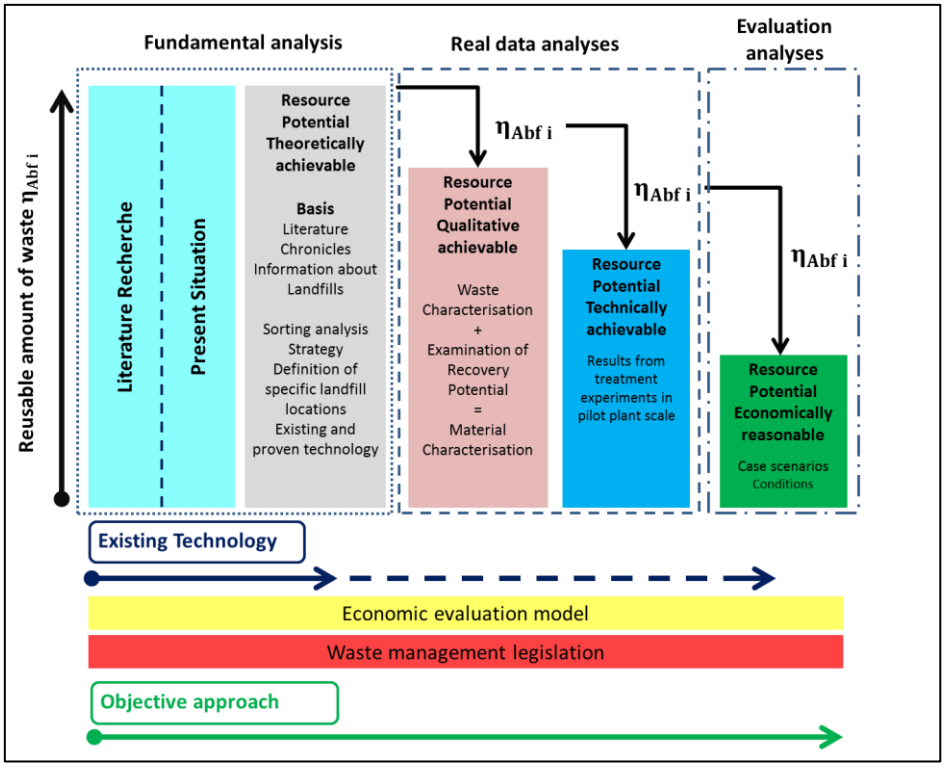

Figure 1: Scheme of the project „Landfill Mining Austria – Pilot region Styria"

Resource Potential of Landfills

In the course of an evaluation of the present situation regarding old landfills in Austria, it was found that especially iron, non-ferrous metals, minerals and materials with high net calorific

value (e.g. plastics, paper, cardboard and wood) can be recovered from landfill bodies and might be applied to recycling processes. To ensure economic feasibility of implementation of a landfill deconstruction project, the theoretical amount of the mentioned valuable materials within the waste body has to be determined. Hence, the deposited waste amounts and compounds landfilled in Styrian dumping sites were investigated. According to the information achieved during this first investigation, especially mass-waste landfills may present interesting objects for deconstruction due to the high presumed resource potential.

Mass-waste Landfills in Styria

In the Federal State of Styria, seven mass-waste landfills in operating state and 18 more which already have stopped waste reception could be found (Status 01.01.2012). Altogether they have a disposal capacity of about 15,395,000 m³. 2,561,393 m³ could still be filled up with fresh waste materials, which represents 26 % of the capacity from the still active operating landfill locations. [7] As already mentioned, the efficiency of landfill deconstruction depends on the recyclable amount of valuable materials. Therefore, the focus of the object investigation was also placed on larger sites with a minimum disposal capacity of 100.000 m^3. In consideration of this volume criterion, only 18 from the primarily found 25 landfills in Styria were analysed more in detail, i.e. information on the quantities and types of waste materials stored, their composition and site-specific data were collected. The results obtained showed that from the mentioned 18 mass-waste landfills, eight can be suspended from any further investigation. Reasons can be attributed to either a very low assumed resource potential due to pre-treatment of the deposited waste, the concerns of landfill operators or the absence of data and deposit records. In case of the remaining ten landfills, an amount of theoretically 5,154,700 tons of recoverable waste material could be observed. Of this amount approximately 1,418,280 tons are paper, paperboard and cardboard (PPC) wastes, 421,720 tons are old glass, 514,720 tons are formed by plastics, 265,780 tons are metal-containing waste materials (MCWM), 1,429,500 tons comprise mineral waste materials (e.g. stones and demolition waste), 739,930 tons are composed of textiles and personal care products, 69,220 tons are constituted by wood, leather and rubber and ca. 295,850 tons are formed by composites (see Figure 2).

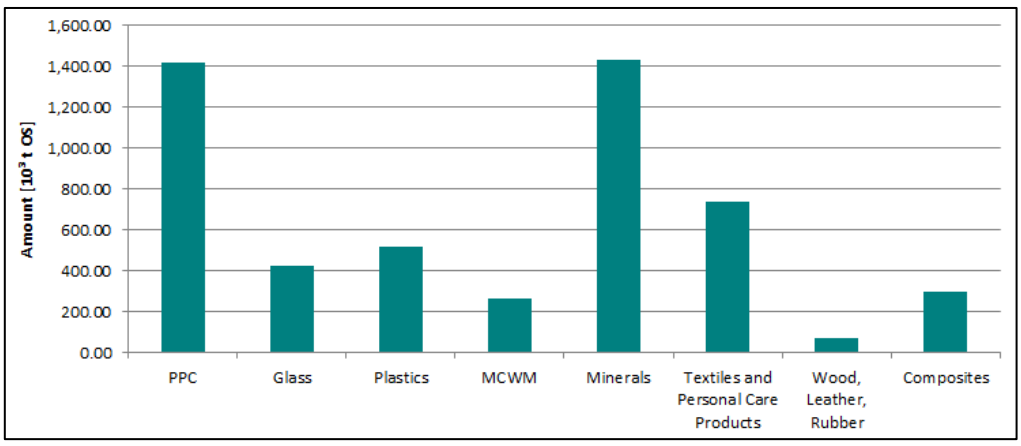

Figure 2: Deposited waste amounts of selected Styrian mass-waste landfill sites

Theoretical evaluation of the resource potential of selected Styrian landfill sites

Due to deposited organic compounds, chemical and biological degradation processes take place within landfill bodies. Consequently emissions which are discharged through landfill gas or by leachate occur. Microbially degradable organic compounds are converted to carbon dioxide and water under aerobic, respectively to methane and carbon dioxide under anaerobic conditions. [8] The term “Theoretical resource potential” therefore represents the

amount of recyclable materials theoretically present in a landfill considering the mentioned biochemical degradation processes and thus forms an important data basis for assessing the economic feasibility of landfill deconstruction. To allow an estimation of the theoretical resource potential of selected Styrian landfill sites, the degree of degradation of biological degradable materials within the waste body was calculated by means of the Landfill Gas Prognosis Model of Tabasaran and Rettenberger [8]. Depending on the selected landfills it amounts values between 51 and 77 % of the stored waste quantity. Using the degree of degradation and the biological degradable portion of each waste fraction (not shown in this paper) the theoretical resource potential for each landfill site was established. The results obtained can be seen in Figure 3.

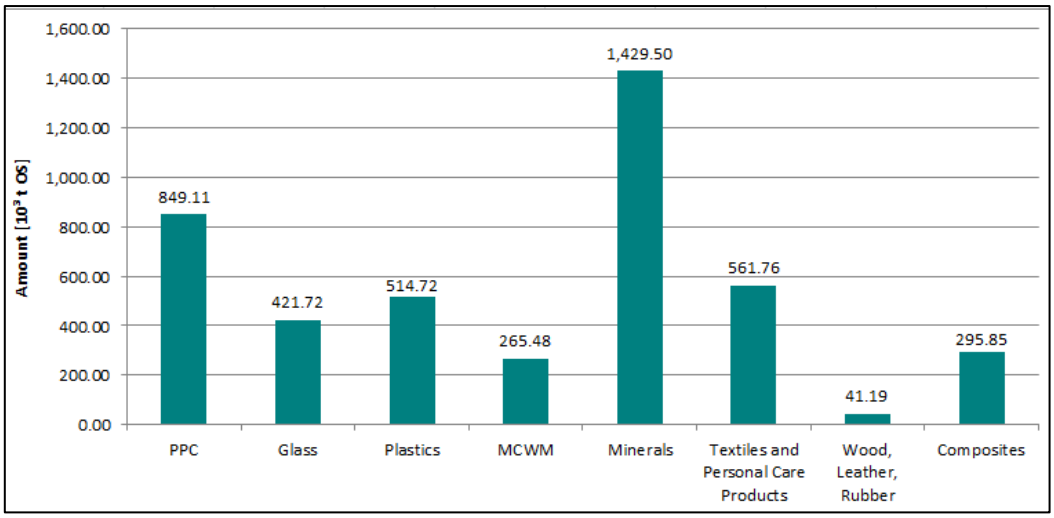

Figure 3: Theoretical resource potential of selected Styrian mass-waste landfills in tons of original substance

Thus, the theoretical resource potential of the selected 10 Styrian landfills can be estimated with approximately 4,379,330 tons of original substance (OS) of reusable waste materials. Regarding the specific water content of each fraction (see Table 1) the theoretical resource potential accounts for 3,176,060 tons of dry matter (see Figure 4).

Table 1: Specific water content of selected reusable waste fractions

Waste Fraction	Water content [%]
PPC	55 (1)
Glass	2 (2)
Plastics	36 (1)
MCWM	2 (2)
Minerals	11 (2)
Textiles and personal care products	44 (1)
Wood, leather and rubber	60 (1)
Composites	36 (3)

(1) Results from an analysis of waste material from a mass-waste landfill in Lower Austria
(2) Results from an analysis of waste materials from a landfill site in Hessen, Germany [9]
(3) Assumption of the Chair of Waste Processing Technology and Waste Management; specific water content of plastics was adopted for composites

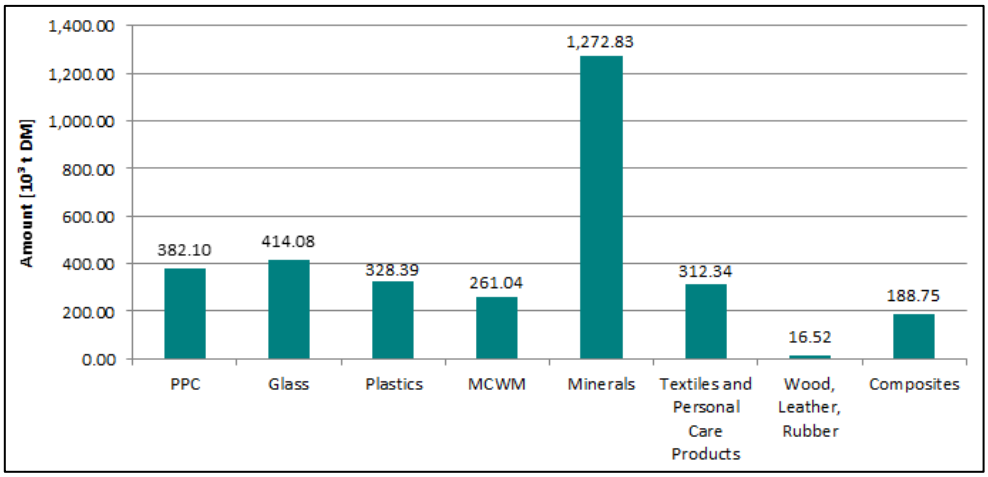

Figure 4: Theoretical resource potential of selected Styrian mass-waste landfills in tons of dry matter

Conclusions

Preliminary results show that selected Styrian landfill sites can contain relative high amounts of valuable waste materials which might be used for energy or material recovery. However, to obtain reliable information about the quality of the excavated waste fractions (e.g. heavy metal content) and to find possible recyclers, further investigations have to be conducted. In this context the Chair of Waste Processing Technology and Waste Management will implement test drillings and/or pittings on one or two chosen Styrian landfills to win representative samples from the waste body. The samples will be chemically characterised and fed to different kind of treatment processes (e.g. sieving, crushing or sorting processes) for recovery of secondary raw materials.

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