SUBMISSION TO GIN 2012
Oral presentation

TOPIC: LANDFILL MINING

POTENTIALS FOR LANDFILL MINING – A Finnish research project
Tommi Kaartinen, Malin Meinander & Margareta Wahlström
VTT, Espoo, Finland

Contacts:
Tommi Kaartinen
Research Scientist
VTT Technical Research Centre of Finland
Biologinkuja 7, Espoo
P.O. Box 1000
FI-02044 VTT, Finland
E-mail: tommi.kaartinen@vtt.fi

ABSTRACT
Key words: landfill mining, characterization, raw materials, sampling, sorting

In Finland the depletion of natural resources has generated interest towards recovering materials, which are already disposed of at landfills. This forms the base for a 2-year Finnish landfill mining project started in 2012 and financed by TEKES, Finnish companies dealing with waste management and treatment and the participating research institutes. This project is a research cooperation project of VTT Technical Research Centre of Finland and Technical University of Tampere. The overall aim of the project is to evaluate the potentials for material and energy utilisation of landfilled waste. Based on this the aim is to examine whether Finnish companies can find new business opportunities within the field of landfill mining. This paper presents more detailed description of the project and preliminary findings from first of the two case-studies included in the project.
**Introduction**

A two-year Finnish research project on landfill mining was initiated in the beginning of 2012. This project tries to build upon earlier international research and give Finnish companies the first impressions on the possible business opportunities in landfill mining mainly in Finland but also abroad. This research project concentrates mainly on landfills for municipal solid wastes. The following chapters offer a look into the project contents and also present some preliminary findings from first of the two case studies which form an essential part of the project.

**Objectives of the project**

The objectives of this research project could be summarized as follows:

- to get hands-on experiences on surveying material contents of landfills
- to estimate material potential in landfills on a national level
- to make preliminary estimates on business potential related to landfill mining in Finland (and abroad)
- to create abilities to start company driven pilot- or demonstration projects

From the results of the case studies, together with historical data on waste generation and landfill characteristics, information is sought about the future potential for material and/or energy recovery from old landfills. Furthermore, the results can be used to develop new concepts and strategies for management of waste at landfills in order to improve the recovery of resources and the sustainability of landfilling of waste without resource potential.

**Research methods**

**Desk studies**

As the first phase of the project information was sought and analysed on the international landfill mining projects with regard to especially utilization of different waste streams, technical execution of the projects, challenges faced as well as economic aspects dealt with in these projects.

At the same time mapping of material potential in Finnish landfills was started. The researchers realize that it is not possible to map the contents of all Finnish landfills but the aim is to give some general impressions on interesting landfill types for mining. This mapping is conducted on the basis of public research, national statistical reports and interviews. One must stress the importance of oral information in relation to operating techniques and contents of especially older landfills.

In the next phase of the project the technologies applied in landfill mining projects are compiled for evaluation. Based on this a summary on methods applicable for mapping, excavation, separation and recovery with main focus on mechanical techniques is done. Also a further technological survey on selected essential technologies including their development needs is conducted.

As the final phase of this research project is the evaluation of landfill mining’s impacts. This phase makes use of both the desk studies described above and the case studies described further in the text. This evaluation consists of different materials’ suitability for material or energy utilization, applicability of excavation and sorting techniques as well as environmental impacts related to
landfill mining. Based on these, preliminary evaluation of possible business potential in landfill mining mainly in Finland is performed.

Case-studies

Two case studies comprise perhaps the most essential part of this research project. These case studies contain excavations on two separate landfills during 2012 and 2013 followed by sorting and characterization of samples from these excavations. The researchers and participating companies see that it is the hands-on experiences that best serve to create understanding on the suitable approaches and applicable techniques for landfill mining.

The field work for the first case study was conducted during summer 2012. The studied landfill contains quite fresh municipal solid waste landfilled at an EU-level landfill during 2001 and 2011. As part of the closure of the landfill vertical gas collection wells with diameter of 90 cm were drilled to penetrate the waste fill up to 30 m of height. The main focus of this first case-study is on the development of approach for characterizing possible landfill mining destinations.

The landfill contains wastes from the past 10 years representing three different periods in local waste management development. The bottom layer of the landfill contains MSW approximately from years 2001-2003 when source separation of bio-waste was not practiced at the area. The middle layer contains waste approx. from years 2004-2009 when source separation of bio-waste was already inaction. Mechanical pre-treatment of all received waste to produce recycled fuel was started in 2009 and thus the topmost layer of the landfill contains mostly rejects from the pre-treatment. This layer was seen to have little interest with regard to landfill mining and was thus discarded from this study.

With data in hand on the average filling heights of the landfill at given times it was possible to keep the different layers of the landfill somewhat separated also in the sampling phase. Also the drilling equipment was able to follow the depth from which each batch of waste was lifted.

Samples for the study were collected by directing all of the waste drilled from the wells to sheds placed on the sides of the wells keeping the different layers separated as well as possible (Figure 1).

Figure 1. Equipment used in gas collection well drilling and a shed for sample collection.
Figure 2 shows the flow-sheet of sampling and further processing of the samples. Altogether three landfill gas collection wells were drilled from which all the material was available for the study. Three wells and two interesting waste layers (bottom and middle) in each well resulted in six sheds of separate samples to be further processed. Only small fraction (approx. 600 litres) of all six samples was sub-sampled from each shed with a clamshell bucket to produce samples for the hand sorting.

Three sheds of the bottom layer samples were combined to form the approx. 22 tons feed to the full-scale mechanical pre-treatment. The same was applied for the samples from the middle layer to produce another feed of approx. 20 tons.

The original plan was to compare the results from hand-sorting as the optimal achievable separation of different waste fraction to the results from full-scale mechanical pre-treatment. In practise it turned out that the drum-sieves in the full-scale equipment were switched after the planning stage to 30 and 70 mm instead of the original 40 and 100 mm. This worsened a bit the possibilities to make comparisons between hand sorting and mechanical pre-treatment.

After the samples were sorted at the site they were delivered to the participating research institutes for further characterization. These characterizations include e.g. further hand sorting of the fine fraction, methane potential of the fine fraction, fuel properties of some of the coarser fractions, types and purity of the plastics and metals and variations in these properties within the landfill. Also preliminary investigations are made concerning the environmental properties of fractions that will not be seen as having potential for utilization.

**Preliminary findings from the first case study**

At the time no results are available on the further characterization of the samples taken and processed in the first case-study. As an example of already existing results Figure 3 shows the mass distributions of different size fractions and mass fractions of different waste fractions in the hand-sorted samples from the landfill bottom layer.
Figure 3. Particle size distribution and mass fractions of different waste fractions in hand-sorted waste samples from the bottom layer of the landfill. The data shown on the right-most picture is combined from the same data for each of the particle size fractions.

Conclusions and future work

Existing preliminary findings from the first case-study could be summarized as follows:

- Samples from the landfill body could be taken quite easily with the equipment used for drilling of gas collection wells. Drill diameter of 90 cm means that also quite big objects are sampled and thus not distort the sampling.

- The samples could be separated both by hands and by full-scale equipment. The chosen approach for sampling, sorting and characterization seems thus quite reasonable.

- No big differences were observed between the samples from the bottom layer of the landfill representing non-source separated (bio-waste) MSW and between the samples from the middle layer of the landfill representing source-separated MSW. This was the case for both the hand sorting and for the full-scale mechanical pre-treatment.

- Moisture of the samples varied quite markedly within the landfill mostly in horizontal direction. The samples containing most moisture were quite obviously also harder to sort. A bit surprisingly the full-scale mechanical pre-treatment was applicable for the samples having moisture content that could be regarded as typical for MSW in disposal conditions. However, the moisture may have had an impact on the sorting efficiency of the full-scale equipment.

As already written above, the work related to this case-study continues during autumn 2012 and rest of the results will be ready by the end of the year. These results will then be used in planning of the latter case-study taking place during 2013. The second case study is aiming to characterize an older Finnish MSW landfill, possibly 30 to 40 years, which will probably be even more fruitful for landfill mining purposes.