

Review on sustainable innovative separation techniques for Enhanced Landfill Mining (ELFM)

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Abstract

Given the demand for space and resources, Enhanced Landfill Mining (ELFM) has been getting more attention. This review, based on a study by OVAM, investigates if current waste separation techniques are sustainable and efficient to use. In this study two landfills have been partially excavated and waste samples have been delivered to different contractors. These contractors processed the waste samples using various separation techniques. The study shows that (1) not all landfills can be used to reclaim materials and/or secondary energy sources (i.e. fuels) and (2) this poses a problem for contractors that need to anticipate the quality of the landfill. Furthermore it is verified that landfills are heavily polluted thus exceeding current norms for re-use in soil applications. It is also stated that more innovative studies could prove beneficial in the field of landfill detection and estimating landfill compositions and energy potentials.

Keywords OVAM . Enhanced Landfill Mining . separation process . waste to materials . waste to energy . caloric value

Introduction

In present times where space is scarce and many resources are needed to uphold the current population standards, more and more attention is given to Enhanced Landfill Mining (ELFM). Not only can it provide a source for recyclable materials and secondary fuels, it also opens up more space that can be redesigned for new purposes. This review aims to illustrate which separation methods can be used and what kind of fractions are recovered. These fractions in general can be sorted in one of the following groups: recyclable materials (waste-to-materials), secondary energy sources (waste-to-energy) or waste fractions (that need to be dumped again). Furthermore some end fractions were analyzed to measure their pollution level thus estimating their value as recyclable materials.

Other end fractions were analyzed to measure their caloric values to see if these fractions can be implemented as secondary energy sources.

Method

Setup

For this study two different landfills were partially excavated. Landfill 1 was constructed between 1975 and 1980 and contained more household related waste, plastics, debris and longer materials (i.e. ropes, plastic stings, nets,...). Landfill 2 was constructed around 1970 and contained more industrial materials (i.e. wires, glass, plastics, foam,...) and asbestos. Because of these industrial-like materials, soil and groundwater around the landfill site is polluted. Each landfill was appointed two contractors who were tasked with separating and valorizing the excavated landfill fraction. About 500 tons of landfill materials were delivered at each of the contractors processing sites. Because the two landfills differ from each other, only contractor A and B can be compared. The same comparison can be made for contractor C and D.

Separation process landfill 1

The suggested separation technique of contractor A, displayed in figure 1, focused on separation in a wet environment (flotation and wet sieving) cleaning the material flows as they are separated. Initially the process started by manually sorting bigger objects. The separation furthermore consisted out of a metal-separation by magnetic conveyors. Soil was separated using hydrocyclones and sieving. The hydrocyclones separate fine sludge which cannot be depolluted anymore since it consists out of too many fine particles. Metal separation was also executed after the flotation by applying a mix of magnetic conveyors and Eddy-currents to split the non-ferro fraction and the rest fraction. This rest fraction contained glass and debris.

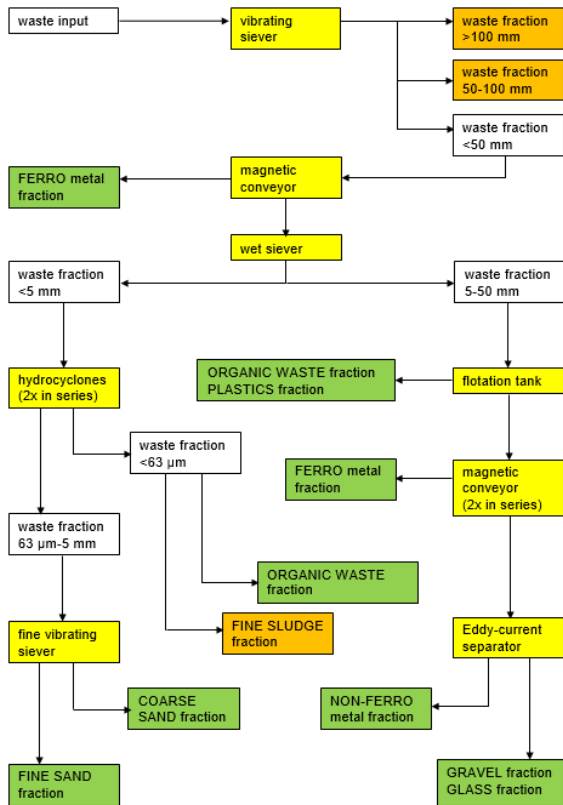


Figure 1: Separation process of contractor A. Separation techniques are colored yellow whereas re-usable and rest fractions are colored green and orange respectively.

Contractor B also started with a manual sorting procedure separating large pieces of debris and removing longer materials that could potentially jam the installation. The major focus in this separation, displayed in figure 2, was to refine solid recovery fuel (SRF) out of the landfill materials. This was achieved by implementing a series of conventional techniques. The installation separated the soil fraction in one branch and SRF in the other branch. Both branches of the installation originate from the rotary sieve where the waste is divided into larger and smaller fractions. The smallest fraction is deprived of their metals and is followed by sieving and windshifting to obtain the different soil fractions. The rest fraction of this branch could be used as SRF. The SRF branch divides the largest fraction into following sub-fractions: wood (by optical sorting), non-ferro (by Eddy-currents), plastics (by optical sorting), debris (by manually sorting), SRF (by sieving) and a rest fraction (by manually sorting).

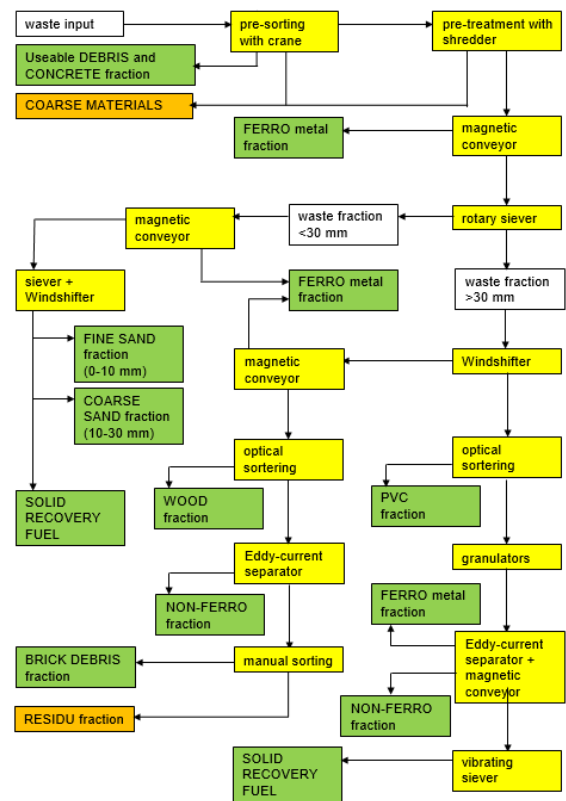


Figure 2: Separation process of contractor B. Separation techniques are colored yellow whereas re-usable and rest fractions are colored green and orange respectively.

Separation process landfill 2

Contractor C suggested a sieving focused separation method for landfill 2 which can be seen in figure 3. The waste was initially manually presorted where larger materials were sent to shredders and the rest was sieved thus obtaining 3 different material sizes (i.e. <40 mm, >40 mm and <150 mm). In a later stage it was decided to take additional refining steps by combining sieving and windshifting. The already processed fractions were combined and then sieved and windshifting into two heavy fractions with different sizes (i.e. <40 mm and 40-150 m) and one light fraction. The largest fraction was sieved again to remove smaller particles given the sticky nature of the waste materials.

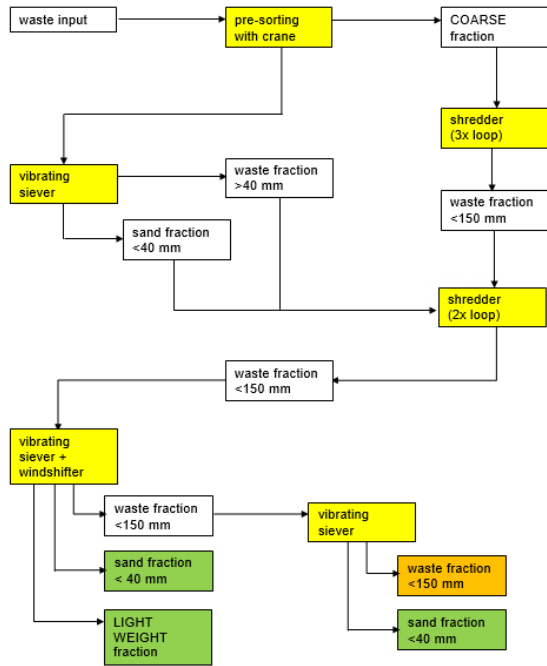


Figure 3: Separation process of contractor C. Separation techniques are colored yellow whereas re-usable and rest fractions are colored green and orange respectively.

Contractor D also employed a sieving focused separation method, displayed in figure 4. Only sieving was applied because the quality of the waste. This was predefined as low and financially not worth separating by advanced methods given the complexity of the waste from landfill 2. Two fractions were obtained, one being a soil fraction (<6.3 mm) and one being a rest fraction (>6.3 mm). After this process a sample was taken from the waste fraction that was manually sorted to give an indication of the materials within.

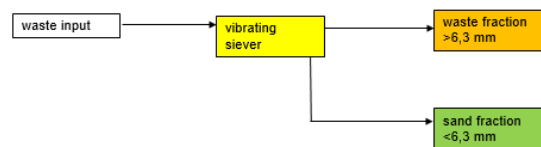


Figure 4: Separation process of contractor D. Separation techniques are colored yellow whereas re-usable and rest fractions are colored green and orange respectively.

Results and discussion

Results landfill 1

Contractor A was able to derive combined soil fractions of 49.62% out of the initial landfill waste. Furthermore the process derived a 19.74% of organic waste and plastics, 15.23% mixed material

fraction of glass and gravel, 6.58% of fine organic waste and 0.48% of metals. About 32.89% of the initial landfill waste fraction needs to be dumped and is mostly generated because of the wet separation technique and the hydrocyclones. It needs to be remarked that the wet separation technique increased the total weight percentage to 124.54%. Based on these results it is clear that the majority of the total fraction (i.e. soil, and the mix of glass and gravel) could be recycled (waste to materials, WtM). When analyzing the WtM fractions however none met the necessary requirements of the regulations concerning soil pollution. Furthermore the plastic and organic fractions were analyzed for their caloric values. These results indicated that the fractions aren't favorable to be reused as a new energy source (waste to energy, WtE) because of their low caloric value of 5.70 MJ/Kg.

Contractor B was able to derive similar combined fractions (52.10%). However a larger WtE fraction (i.e. SRF) of 29.6% was obtained. The process also derived a 5.6% plastic fraction, 2.0% debris and 1.4% wood. The rest fraction that needed to be dumped was about 9.2% of the initial waste. The soil and debris was defined as WtM fractions and analyzed accordingly for their pollutions. The soil fraction did not meet the requirements and exceeded multiple thresholds for heavy metals. The debris fraction however did not exceed any requirements of the regulations concerning soil pollution. The SRF, plastics and wood fractions were analyzed on their caloric values because of their potential to be used as WtE. It was determined that the SRF had a low caloric values between 8.35 MJ/Kg and 13.70 MJ/Kg respectively. The plastic fraction had an average caloric value of 12.4 MJ/Kg. The wood fraction on the other hand had an increased caloric value of 17.4 MJ/Kg which is above average for most wood fractions derived from landfills. Because of the easily refinable debris and wood fractions, both are considered above average quality for landfill materials. However it still needs to be discerned that these fractions hold a rather low weight percentage in the landfill thus making it financially unfavorable to process the waste for these fractions only.

Comparison landfill 1

Both separation setups, though different in working process and with another focus, yielded similar results regarding the overall fractions that could be recycled (WtM) or implemented as secondary fuels (WtE). A summary of these results can be found in figure 5. Also similar for both setups is that all the total WtM fraction is too polluted after separation thus needing to be cleaned by physicochemical techniques. The focus of both techniques is clearly visible in the end fractions. The separation process of contractor A yielded more clean fractions although still exceeding regulations for reuse (i.e. soil fractions). This fraction however contained more moisture because of the wet separation techniques. Contractor B on the other hand delivered an 11% larger WtE fraction but less clean. Furthermore it can be discerned that the amount of metals in the initial waste fraction is very low. Also the caloric value of the WtE fraction is rather low suggesting that landfill 1 might not be suited for generating secondary fuels.

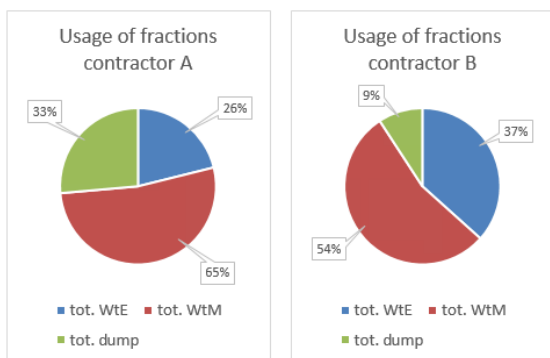


Figure 5: Comparison of the results between contractor A and B.

Results landfill 2

Contractor C was able to obtain a heavy and light waste fraction around 48.37%. This light waste fraction mostly consisted out of plastics but was physically similar to the heavy fraction. A soil fraction of 52.85% was obtained. Analysis results indicate that the soil was too polluted to be reused again in construction applications without cleaning thus exceeding the norm for soil pollution. The main pollutants were oil, heavy metals and benzo(a)pyrene. The caloric value for the waste fraction was analyzed and indicated a caloric value of 6.96 MJ/Kg, which can be considered as low. It needs to be discerned that a more excessive separation method would yield more refined end fractions with higher caloric values. Although

indicated to be present when excavating, asbestos was not visually found in the end fractions.

Contractor D suggested a simple separation method that yielded a waste and a soil fraction. This soil fraction was about 81.40% of the total sample where the waste fraction was about 18.60%. The waste fraction was manually sorted into three fractions consisting out of carpet debris and plastics (16.91%), mixed glass and stone (1.47%) and metals (0.22%). Here as well, asbestos was not visually found in the end fractions. The soil fraction was analyzed and results indicated that some pollutants (oil, heavy metals, benzo(a)pyrene and PCB's) exceeded the thresholds for soil pollution. The caloric value was not determined as the end fraction was still too complex which would not reflect on the real caloric values of potentially refined fractions.

Comparison landfill 2

The separation process suggested by both contractors is rather limited thus not yielding refined end fractions. It is important to notice that a more intense separation process would yield more refined end fractions with higher caloric potential. A summary of these results can be found in figure 6. Furthermore because of this separation a limited amount of fractions were recovered making it more difficult to compare the weight percentages. Given the results there is also a presumption that the waste fraction was more heterogeneous than initially expected. This is suggested by the large difference in soil fractions between the two separation methods. Similarities in the end fractions however can be found in the level of pollution where both waste materials contained benzo(a)pyrene, heavy metal and oil concentrations.

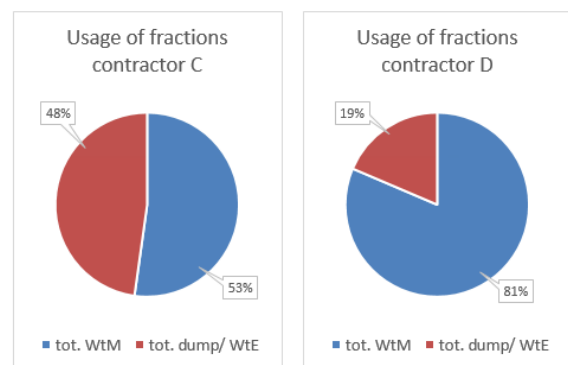


Figure 6: Comparison of the results between contractor C and D

Discussion

For both landfills the majority of the WtM fractions can be reused after cleaning. Most of the other non-soil WtM fractions needed to be cleaned as well. In general cleaning these fractions result in more refined and clean fractions but also in a fraction that needs to be dumped. Furthermore the cleaning of these fractions is not always financially viable to do for the contractors. From a financial point of view the contractors rather want to dump some fraction than further process it. Landfill 1 has a low to medium caloric value and seems hardly viable where landfill 2 had low caloric values and would not be suited to deliver secondary energy sources. It always needs to be discerned that higher caloric values can be achieved by a more intensive separation process although it would not always be financially viable to do so. The intensity of the separation process is difficult to estimate in advance based on the caloric values. A more refined product will yield higher caloric values. The waste samples given however will have lower caloric values because of impurities. A sample thus needs to be separated and intensively refined to estimate how big the caloric value is and how large the end fractions will be. The more waste that can be processed the more financially viable the separation will be.

From a technical point of view it can be remarked that sticky and longer materials may jam the installations more quickly resulting in a lower efficiency. In general wet separation techniques clean the separated fractions. This could be beneficial for mildly polluted landfills where the wet separations would remove enough pollutants to meet the thresholds. However a wet process leaves wet end fractions as well as a larger end fraction to dump because of the pollution it contains. Asbestos was described during the excavation of landfill 2 but was not visually found during the separation. It still can be present in a (grind) end fraction because of the difficulties to separate asbestos. This is similar to the separation problems with grind or debris and glass, where there is no efficient technique to separate these two fractions.

It is required that more innovative studies are issued regarding separation and detection techniques. Especially detection techniques that can provide an estimation of the landfill composition and a caloric value would be a major asset.

Conclusion

Landfills can differ from each other thus are in need of specific separation techniques when implementing ELM. All results showed that WtM fractions have an increased chance that they need to be cleaned. The cleaning process will make the entire process more costly and will generate a fine sludge fraction that needs to be dumped. Furthermore WtE fractions are difficult to judge when receiving the landfill waste.

In this study landfill 1 is hardly suited for generating secondary energy sources. Caloric values indicated that landfill 2 is not suited as a secondary energy source. In general larger amounts of landfill waste will make the process more cost efficient and will cover expenses for a sample to run through the installation. At last it needs to be discerned that not all fractions can be separated (i.e. asbestos and glass) and that it would be beneficial to have more studies in the field of landfill detection and analysis regarding waste composition and caloric values.