How is MBT-technology in 20 years?

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Abstract

Due to considerable changes in landfilling strategies in Germany and Austria during the last decade MBT technology has become one of the most important treatment procedures for municipal solid waste besides incineration. Reduction of environmentally relevant emissions has been in the focus of interest. After some years of experience this request is proved to be accessible. The future challenge in waste management will be the use of resources from waste in a proper way. The objective is not only the avoidance of negative effects, but the improvement of positive effects by material recovery, energy production and carbon sequestration. The carbon cycle and the effect on climate will be a crucial issue. In this paper data of four sorting analyses are presented. Input materials of four MBT plants were investigated and assessed in terms of the intended purpose. About 5 to 10 % were sorted for material recovery. Improved sorting technologies can provide about 30 % for heat production. Data of carbon sequestration in landfilled MBT material are presented and compared to municipal solid waste incinerator (MSWI) bottom ash. The total organic carbon (TOC) content differs from MBT material (average ~ 17 % DM) to MSWI bottom ash (average ~ 2 % DM). Finally incineration of municipal solid waste containing biogenic materials and food waste with high water contents is discussed.

Inhaltsangabe

Im Zuge der Änderungen der Ablagerungsstrategien in Deutschland und Österreich wurde die MBA Technologie neben der Verbrennung zu einer der Hauptbehandlungsarten von Siedlungsabfällen. Das Hauptaugenmerk lag auf der Vermeidung negativer Auswirkungen auf die Umwelt. Nach einigen Jahren ist mittlerweile klar, dass dieses Ziel erreicht werden kann. In den nächsten Jahrzehnten wird die größte Herausforderung der Abfallwirtschaft darin bestehen, die Ressourcen des Abfalls zu nutzen. Nicht nur negative Effekte verhindern, sondern positive lukrieren, muss zum Ziel werden. Der Blickpunkt muss auf den Kohlenstoffkreislauf und Klimarelevanz gelegt werden. In der vorliegenden Arbeit werden beispielhaft Daten aus vier Sortieranalysen präsentiert. In vier verschiedenen MBA Anlagen wurde das Inputmaterial bewertet. Zwischen 5 und 10 % könnten zur stofflichen Verwertung genutzt werden. Durch bessere Sortierung wären zusätzlich bis zu 30 % des Materials für die Energieerzeugung geeignet. Außerdem werden Daten zur Kohlenstoffsequestrierung von MBA Deponien im Vergleich zu Verbrennungsschlacke präsentiert. Der organische Kohlenstoffgehalt (C_{org}) liegt bei MBA Deponiegut im Mittel bei 17 % TM, während Schlacke nur einen Kohlenstoffgehalt von 1 – 2 % TM aufweist. Die Verbrennung von organischer Substanz mit hohem Wassergehalt wird diskutiert.

Keywords

MBT technology, material recovery, sorting analyses, carbon sequestration

MBA Technologie, Recycling, Sortieranalysen, Kohlenstoffsequestrierung

1 Introduction

During the last decades waste management has mutated from prevention of negative environmental impacts by waste reactivity and end of pipe strategies into improvement of provident measures to minimize emissions by the landfilled materials in advance. This purpose has resulted in the landfill ordinances for the compulsory pretreatment before landfilling. Mechanical-biological treatment (MBT) and municipal solid waste incineration (MSWI) are the most relevant procedures to reach this goal. In addition resource recovery and the use of waste have increasingly gained in importance the last years. In this context sorting technologies have become an indispensable integral part of current strategies. Biological and thermal treatment moved from competitive technologies to complementary measures within a comprehensive waste management concept. The efficient use of resources including materials and energy is aimed for. The markets for these resources have developed at different quality levels and economical reasons are in most cases the determining factor. Because all measures affect the global carbon cycle we have to consider the impact and the consequences of all waste management activities in this context. The task for politicians will be to adjust the markets for waste resources and to take into account ecological aspects in a holistic approach. This paper focuses on two main points:

- Determination of potential resource recovery based on sorting analyses
- Benefits by carbon sequestration and discussion on energy efficiency

2 Materials and Methods

2.1 Sorting analyses

Four examples of sorting analyses with different purposes and methods are presented. Analyses A – C focused on the quantification of different fractions, analysis D on the assessment of thermally usable materials. The material composition was consistent in all cases with the usual input intended for the biological treatment in a MBT plant.

Example A: residual waste (37,700 kg comprising 10 charges) was manually sorted. The material was not shredded or treated anyway else. The following fractions were separated:

Agrofoils, aluminum tins, batteries, coloured foils, electronic scrap, stained glass, clear glass, untreated wood, treated wood, cables, crate wood, magnetic separator, medicaments, engine oil bottles, nail polisher, non-packaging plastics, paper, PET-bottles, plastic pipes, PS, X-ray photographs, carpets, transparent foils and packaging materials.

Example B: Residual waste (79,900 kg) was sorted automatically. The material was not shredded. The selected fractions were metals and contraries.

Example C: Residual waste (40,380 kg) was manually sorted with the focus on two charges. The material was not shredded or treated anyway else. The sorted fractions were green, blue and transparent PET-bottles, other hollowware, foils, ferrous metals and non-ferrous metals.

Example D: Residual waste (180,000 kg) was sorted automatically. The material was shredded and dried using the heat that is generated by the biological treatment. Metals and wood, however, were sorted for material recovery. The thermal fraction was divided into a fraction from 6 to 40 mm and a fraction from 40 to 70 mm.

2.2 Determination of carbon contents in MBT landfills

Carbon contents were determined by investigation of 34 MBT landfills and MBT materials intended for landfilling. They covered the variety of Austrian MBT materials.

Total carbon and inorganic carbon were measured using the CNS analyzer (VarioMax). The total organic carbon (TOC) content was calculated by subtracting the inorganic carbon from the total carbon.

2.3 Determination of carbon contents in MSWI bottom ash and water evaporation in combusted MBT materials using thermal analysis

Quantification of carbon contents in MSWI bottom ash was carried out using an instrument for simultaneous thermal analysis (STA 409 CD, Netzsch GmbH).

Twenty-four samples of MSWI bottom ash ready for landfilling or already landfilled were analyzed. The samples originated from different plants and landfills respectively and covered the range of Austrian MSWI bottom ashes. The samples were subjected to the heating program from 30°C to 950°C with a heating rate of 10 K min^{-1}. By means of thermogravimetry the weight loss is measured. The CO_2 ion current (mass 44) caused by combustion of organic matter and carbonate decay > 650 °C is recorded by the mass spectrometer. It enables to distinguish weight losses by CO_2 release or water (mass 18) evaporation.

3 Results

3.1 Sorting analyses

Results of sorting analyses are compiled in tables. The material recovery potential of sorting analysis A was found to be 7 ± 1.9 % (w/w). A detailed list of different fractions and the portion of the total residual waste charges is presented in Table 1.

Table 1: The fractions of the material sorted for recovery in example A.

fraction	percentage	fraction	percentage
magnetic separator	14.3	treated wood	1.6
agrofoils	13.7	PET-bottles	1.3
paper	12.4	aluminum tins	0.9
packaging materials	11.9	batteries	0.4
carpets	9.2	PS	0.4
non-packaging plastics	7.6	stained glass	0.3
transparent foils	6.9	clear glass	0.3
colored foils	6.6	crate wood	0.3
untreated wood	3.8	medicaments	0.1
cables	3.7	engine oil bottles	0.1
electronic scrap	3.3	nail polisher	0.1
plastic pipes	2.3	X-ray photographs	0.1

According to sorting analysis B the total potential for material recovery was assessed by 4.0 % (w/w).

According to sorting analysis C the potential for material recovery amounted to 9 ± 3.3 % (w/w). Details on composition and percentage are compiled in Table 2.

Table 2: The fractions of the material sorted for recovery in example C.

fraction	percentage	fraction	percentage
foils	44.1	non-ferrous metals	6.4
ferrous metals	23.7	PET blue	3.1
hollowware	10.5	PET green	1.9
PET transparent	10.3		

Sorting analysis D led to following results displayed in Table 3.

Table 3: The fractions of the input material in example D.

fraction	percentage	fraction	percentage
6 – 40 mm	30	wood	5
40 – 70 mm	20	metals	2

The rest amounted to about 40 %.

3.2 Organic carbon contents in MBT materials and MSWI bottom ash

Figure 1 displays the different carbon contents of MBT and MSWI output materials for landfilling. The mean TOC content of the MBT materials was about 17 ± 2.5 % DM. The MSWI output reached a mean content of about 2 ± 1.4 % DM. The average difference between carbon contents in MBT waste and MSWI bottom ash is about 15 % organic carbon DM.

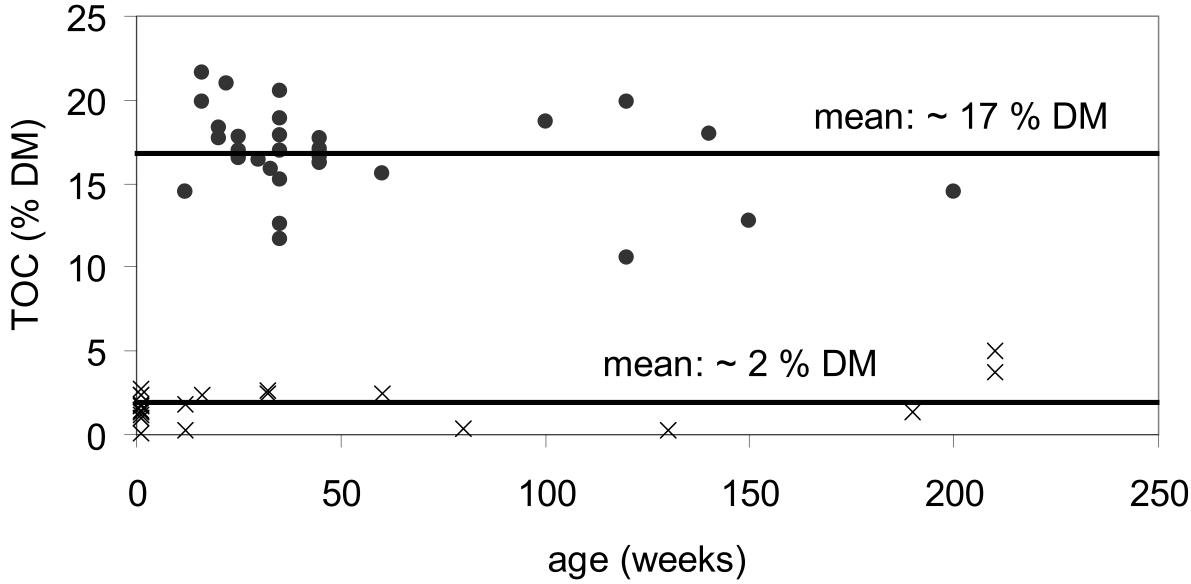

Figure 1: The TOC values of material from landfilled MBT material (●) and slag from MSWI bottom ash (×)

During MSW incineration two effects occur that reduce the efficiency of thermal utilization and should be taken into account: evaporation of water and the decay of carbonates. Carbonates are deteriorated at temperatures > 650 °C, leading to CO_2 release (Smidt et al., 2009). In addition the decay is an endothermic reaction with energy uptake which lowers the energy efficiency. In the MBT process a considerable amount of “stable” carbon remains in the matrix and is not released into the atmosphere. Figure 2 illustrates the exothermic processes of organic matter combustion and the endothermic reaction of the carbonate decay.

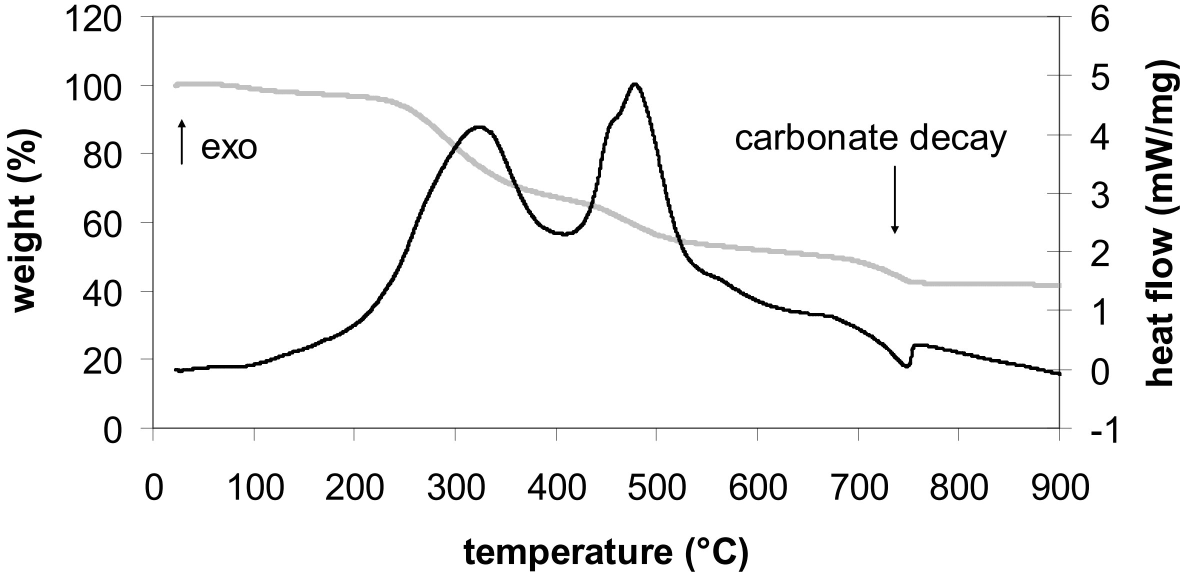

Figure 2: Weight loss and heat flow curve of MSW indicating the decay of carbonates by the weight loss and the endothermic reaction

Evaporation of water as well takes energy and diminishes the energy efficiency of MSW incineration. Materials (e.g. biogenic waste and food waste) with high water contents should be separated carefully and subjected to biological aerobic or anaerobic processes. Figure 3 displays the endothermic reaction of water evaporation at about 100 °C.

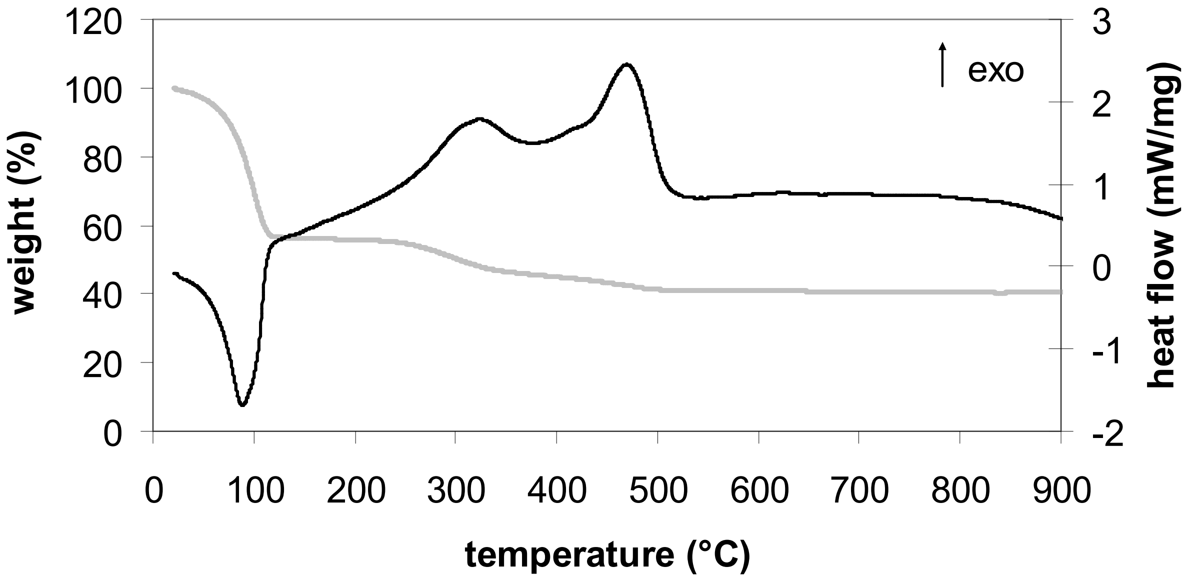

Figure 3: The mass loss and the heat flow (enthalpy) of biogenic waste with an original water content

The calorific value of the dry material is indicated by the exothermic reaction up to 550 °C indicated by the heat flow curve, respectively by the area below the heat flow curve.

4 Discussion

The next 20 years MBT technology will have to focus more on the one hand on the improvement of the material recovery and on the other hand on the maximization of carbon sequestration of all materials that cannot be used for energy production in MSWI plants.

The results of the sorting analyses display a potential for material recovery of about 5 to 10 % of the input of the biological treatment of MBT plants. Only in example A the recovery of the sorted fractions is actually realized. In examples B and C the sorted materials usually end up in the MBT process without sorting. In example D about 20 % of the input material is actually separated instead of the assessed 60 %. The additional amount for material recovery was about 7 %; for energy recovery about 30 %. Even though the results are not transferable one to one, the potential implies the improvement of sorting technologies. In all cases of the sorting analyses investigated the improved recovery was recognized as an economically interesting step even when low and strongly fluctuating prices of raw materials seem to alienate the runners of the plants.

The biological treatment of MBT plants must become compulsory for all fractions of the residual waste, which cannot be used for energy production in MSWI plants. The heavy fraction with a usually high content of wet, biogenic material is improper for energy production (by means of incineration). Moreover, the inorganic fraction with a high content of carbonates is not just useless but problematic, as the decay of carbonates at temperatures > 650 °C is an endothermic reaction and leads to additional release of CO_2 to the atmosphere with loss of energy.

The carbon storage in MBT landfills seems also to be a crucial challenge for the MBT technology in the future. In the context of climate change the benefit of MSWI is energy production, the positive impact of MBT waste is carbon sequestration. The difference in the carbon content of about 15 % DM between landfilled MBT and MSWI output seems to be a veritable result.

A crucial research topic which is in the focus of interest targets the quality of organic compounds indicated by the TOC. The determined content of 17 % DM in MBT materials cannot be considered as the long-term stable carbon pool. The amount of carbon, which is stored in the landfill over centuries, will be a percentage of this value. Investigations of degradation rates under different conditions, stabilization effects by mineral compounds, more details about microbial processes and adequate testing methods will be future research projects.

Despite many open questions it can be assumed that MBT landfills develop towards real carbon sinks. This aspect has to be taken into consideration in the discussion about balances, benefits and carbon credits.

Waste management in 20 years will concentrate on the fate of carbon and on the efficiency of measures to slow down the turnover rates. Therefore the processes of material recovery, energy production and carbon sequestration should be optimized. In this context MBT technology ranks in a key position as an interface of material recovery, energy production and carbon sequestration.

5 Literature

Smidt E., Meissl K., Tintner J., Ottner F.	2009	Interferences of carbonate quantification in municipal solid waste incinerator bottom ash: evaluation of different methods. Environ Chem Lett, in press, Springer

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