Capability of MBT to Meet Treatment Targets in Different EC States

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Was kann MBA leisten im Hinblick auf verschiedene Zielvorgaben in Europa?

Abstract

The focus of the EU landfill directive is the reduction of biodegradable waste destined for landfill on a solely quantitative basis. Trials on the bio-mechanical treatment and its effect on the landfill behaviour show that the quality of the remaining organic fraction for landfilling should be considered because it is more relevant than the quantity of biodegradable waste, in terms of the level of gaseous emissions from landfill. This leads to the incongruous situation where one could treat the waste to reduce the environmental impact of landfill, with respect to landfill gas emissions and leachate, by more than 90 % but still not achieve the EU landfill threshold values. This paper indicates how the change of biodegradability which is achieved during the mechanical and biological treatment (MBT) process and what treatment periods are required to achieve treatment targets specified within EU.

Keywords

MBT, stabilisation, landfill, mechanical and biological treatment, respiration rate; AT4; BM100; EU landfill directive

1 Introduction

The main reason for establishing the EU Landfill Directive (99/31/EC) was to reduce the environmental impact of landfills. The biodegradable fractions in the waste have been identified as the cause of landfill gas emissions and leachate. Consequently the EU-landfill directive set targets to reduce the quantity of organic destined for landfill (see Table 1).

Table 1 Landfill Directive (99/31/EC) targets

Target percentage reduction in landfilling of biodegradable waste	Requirement	Countries heavily reliant on landfill will be able to claim derogations to delay meeting targets by 4 years, e.g. UK
75% of the 1995 levels	By 2006	By 2010
50% of the 1995 levels	By 2009	By 2013
35% of the 1995 levels	By 2014	By 2019

In Germany, the Landfill Ordinance in 1993 set a landfill guideline requiring that no material may be landfilled if it has an organic carbon content higher than 3 %. In Austria a similar guideline has been established. This implied that municipal waste had to be incinerated prior to landfilling. The high level of public hostility to incineration resulted in a great deal of interest in techniques that could be developed as an alternative treatment process, which was also capable of meeting the guideline. One of these techniques was mechanical and biological waste treatment (MBT).

Mechanical Biological Treatment (MBT) is a generic term for the integration of a number of waste management processes such as materials recovery facilities (MRF), refuse derived fuel (RDF) production, mechanical separation, sorting, composting and pasteurising.

There are a number of MBT plants that have been built in the EU and several are under construction. In order to minimise environmental nuisance for odour, fly and noise nuisance, these facilities are often required to be housed within a building and normally under negative pressure. The use of bio-filters is also required to treat any odour problems.

The MBT process is designed to take residual or black bin waste and process it so that valuable recyclable materials can be separated out and the biomass or "compostable" element is separated out and processed through an In Vessel Composting (IVC) or an Anaerobic Digestion (AD) system.

Extensive research was carried out in a research project entitled: "Mechanical-biological pre-treatment of municipal solid wastes before landfilling", funded by the German Ministry for Education, Science, Research and Technology. In Austria and several German states and districts additional projects have been conducted. The relationship between the degree of biostabilisation by MBT and behaviour of the treated material in landfill was focus in several of these projects.

The trials on MBT were mostly conducted in large scale plants where different technologies were examined including both mechanical, aerobic and anaerobic processes and technologies.

The behaviour of waste in landfill has been investigated by various research projects involving landfill simulation trials. This means that, depending on the question investigated, landfill cells of varying sizes were simulated in the laboratory or on a semi-technical scale. The larger the simulated landfill section and the closer the established conditions are to the real world situation, the easier it was to transfer simulation results to full scale landfills. The aim of these experiments was to measure the maximum potential for emissions (leachate and landfill gas). As these landfill simulation trials were very complex, costly and time consuming, it was necessary to find appropriate criteria from which the landfill behaviour and, therefore, the success of MBT could be determined.

2 Degradation

In order to obtain the baseline data required for the designing biological treatment facilities for residual waste, numerous trials and experiments with different degradation methods and technologies were carried out.

Degradation of organic matter and, therefore mass reduction is the main parameter to determine the efficiency of the biological treatment. It is primarily determined by the characteristics of the input material as well as by oxygen supply, water content and temperature. Therefore, methods such as homogenisation, aeration, temperature control and irrigation can provide good tools for managing the degradation process, particularly its early stages.

Figure 1 shows various biodegradation levels achieved by different composting technologies. It can be seen that the processing of residual waste in a composting box (System 4) can yield organic dry matter degradation levels of more than 45 % during a four-week composting period. Such good results are an indication of optimum composting conditions. Similar composting conditions and biodegradation levels were observed for two other intensive composting systems (System 3 and 5). It should be mentioned that these were trials conducted in the early days of MBT development and do not represent the current common practice in terms of large scale operational facilities. Especially the treatment time is at the low end of the example. But the figure shows the impact of different technical means to control the biological process.

The simple (control) composting technology (System 1) showed a significantly reduced rate of organic matter (oDM) degradation and required 58 weeks to reduce it by more than 40 %. This was primarily due to insufficient aeration, caused by an incompatible combination of mechanical and biological processing technologies. The mechanical processing phase resulted in fine material without sufficient structure and structural stability to facilitate passive airflow driven by temperature gradients. Therefore, this simple composting technology, which did not comprise a forced aeration system, was not suitable for composting the fine waste material used in the trial. When using composting technologies that rely on passive aeration it is important that sufficient coarse and structurally stable waste materials remain in the composting material after mechanical treatment in order to facilitate adequate oxygen supply (FRICKE and MÜLLER, 1999).

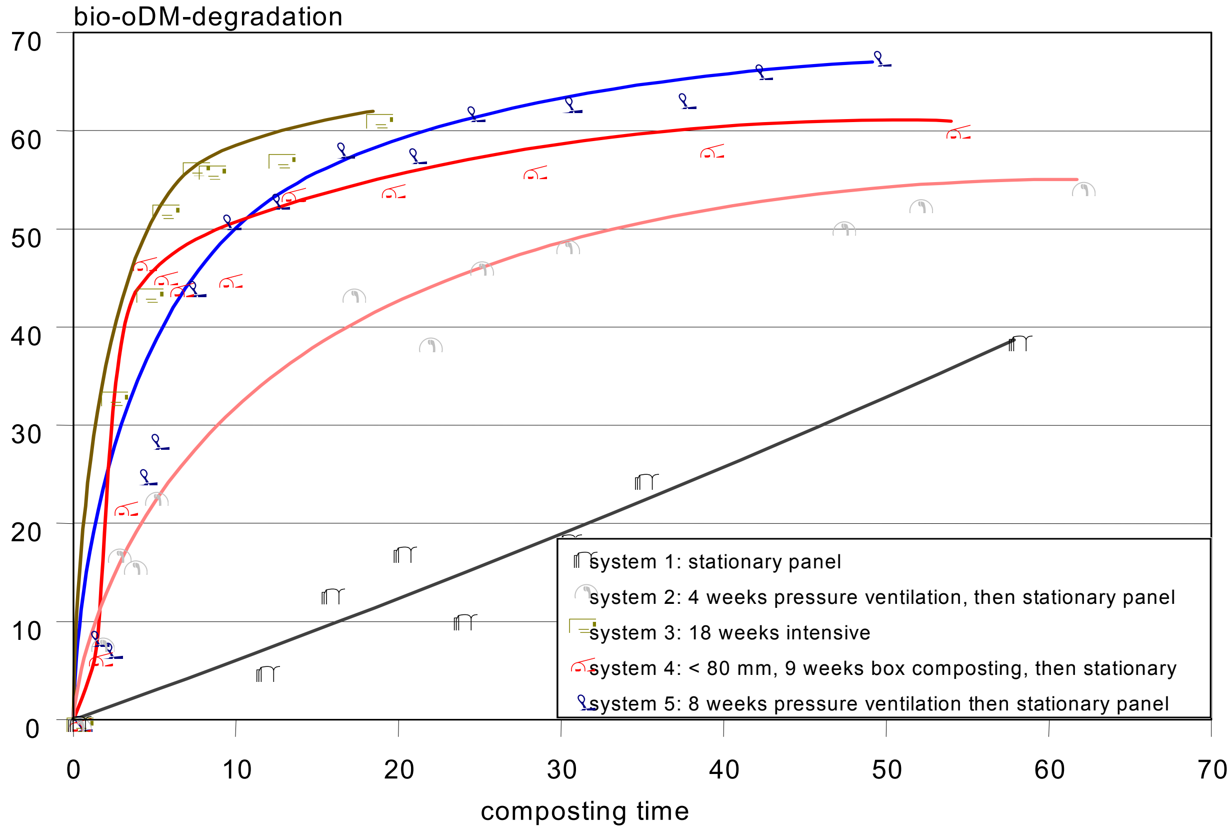

Figure 1 Effect of various composting technologies employed for the processing of residual waste on the level of organic matter degradation (FRICKE and MÜLLER, 1999)

3 Stabilisation of organic matter

Respiration activity (BOD4)[1] has been proven to be suitable for the assessment of the biological degradability and consequently the stability of the organic matter. The parameter measures the oxygen consumption within 4 days, as it is the case in assessing the efficiency of waste water purification. The assessment is made using a sample adjusted to an optimum water content (approx. 50% fresh matter) at 20º C.

Plotting the development of the respiration activity of composted material over time provides diminishing BOD4 values over time. Intensive and highly mechanised composting operations are able to stabilise waste materials faster than low-tech systems. Figure 2 shows the range of the decrease of BOD4 over composting time for advanced composting technologies. The graph also indicates the threshold values in the German Landfill Ordinance.

[1] In Germany and Austria respiration acitivity is abbreviated as “AT4”. The abbreviation “BOD4” used in this paper means the same and stands for “biological oxygen demand within 4 days”. The methodology is defined in the German landfill regulation.

Similar responses can be seen with some other parameters like TOCeluate, gas formation rate within 21 days (GFR21), cellulose and cellulose/lignin ratio but they are less suitable for the determination of the stability degree than BOD4 (FRICKE and MÜLLER, 1999).

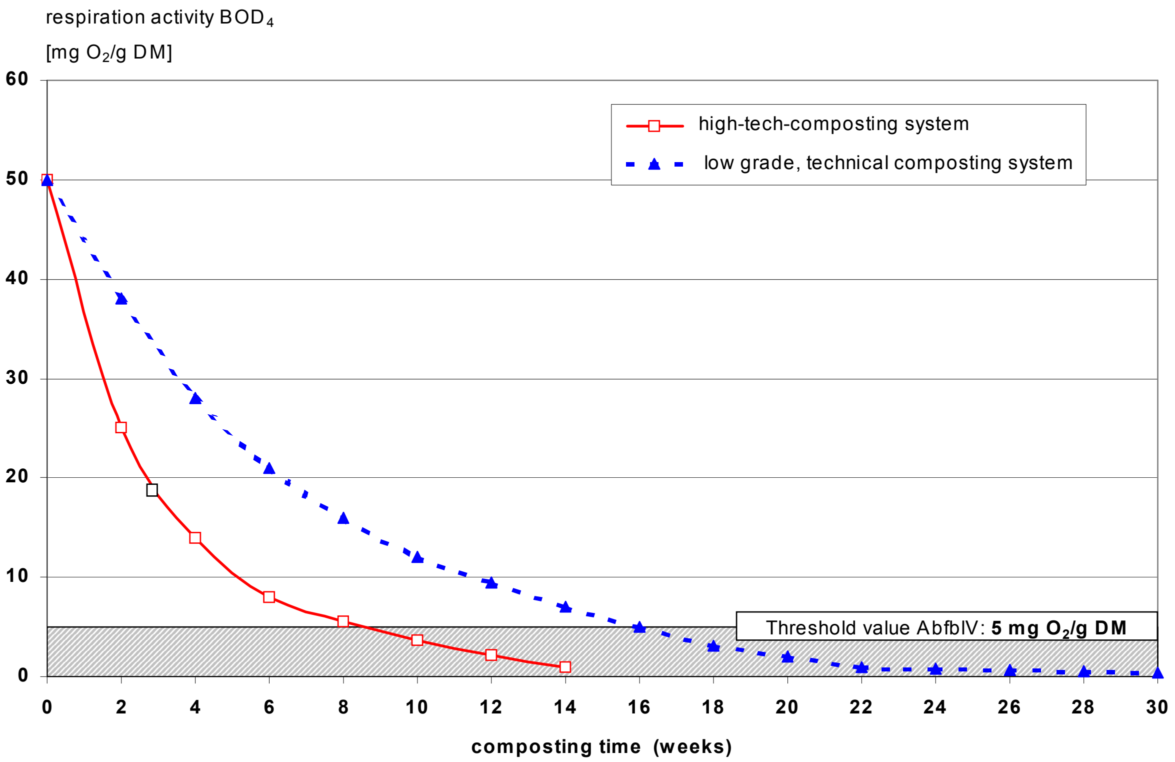

Figure 2 Effect of composting technologies on the rate of bio-stabilisation

4 Landfill Simulation trials

The main focus of landfill behaviour investigations was the determination of the emission potential of material processed using under landfill conditions, and on the estimation of temporary emission development. The long-term behaviour of MBT pre-treated material was examined in different types of Landfill-Simulation-Reactors (LSR).

Waste samples from different MBT plants with different biological treatment procedures have been investigated (aerobic treatment in windrows, containers and tunnels, anaerobic pre-treatment in a one-step dry fermentation under thermophilically conditions with aerobic post treatment step). The waste fractions were sampled after different treatment durations in order to determine the rate of decomposition.

The additional work program for each sample consisted of:

- chemical solid waste analysis to characterise the content of organics (loss on ignition, TOC, COD, cellulose, lignin and easy degradable organic matter), content of total nitrogen (TN), and the content of metals)

- biological short term test (respiration activity, gas formation activity, toxicity tests) to assess biodegradability
- leaching tests series to estimate the soluble emission potential of the waste samples (TOC, COD, BOD, TN and metals). Leaching test were carried out in a sequence of 5 leaching steps.

Because of the large number of assessments only the most important, summarized results can be summarised here:

Table 2 shows the result of the landfill simulation trials. Compared with untreated waste the landfill gas potential of bio-mechanically treated waste is reduced by 90 % - 95 %. The potential of organic carbon in the leachate can also be reduced up to 95 %, because no acid phase occurs in the landfill. MBT was also found to reduce nitrogen leachate emissions decrease by about 80 to 90 %.

The low emission potential of bio-mechanical pre-treated MSW leads to a very low gas formation activity and to a very slow mobilisation of organics and nitrogen into the leachate. Tests in Landfill-Simulation-Reactors have demonstrated that the half-life values of gas formation activity extend by a factor of 10 for well stabilised MSW.

Table 2 Range of organic carbon, nitrogen and chloride transfer by gas and leachate, minimum values represent the stabilisation degree reached by state of technology today (HÖRING et al., 1999)

Emission Potential		Unit	Untreated MSW	Mechanical-biological treated MSW
carbon transfer by gas	Gas formation	[Nl/kg dm] [g C_{org}/kg dm]	134-233 71,7-124,7	12-50 6,4-26,8
transfer by leachate	TOC	[g/kg dm]	8-16	0,3-3,3
	Total Nitrogen	[g/kg dm]	4-6	0,6-2,4
	Cl^-	[g/kg dm]	4-5	4-6

5 Parameters to judge the landfill behaviour

As it´s not possible to conduct LSR as a regular measure to judge the efficiency of a MBT with respect to the landfill behaviour another appropriate parameter is required. In the above research projects a lot of different parameters have been test regarding this to determine suitable candidates. Figure 3 shows that there is a good correlation between the BOD4-value and the potential gas formation.

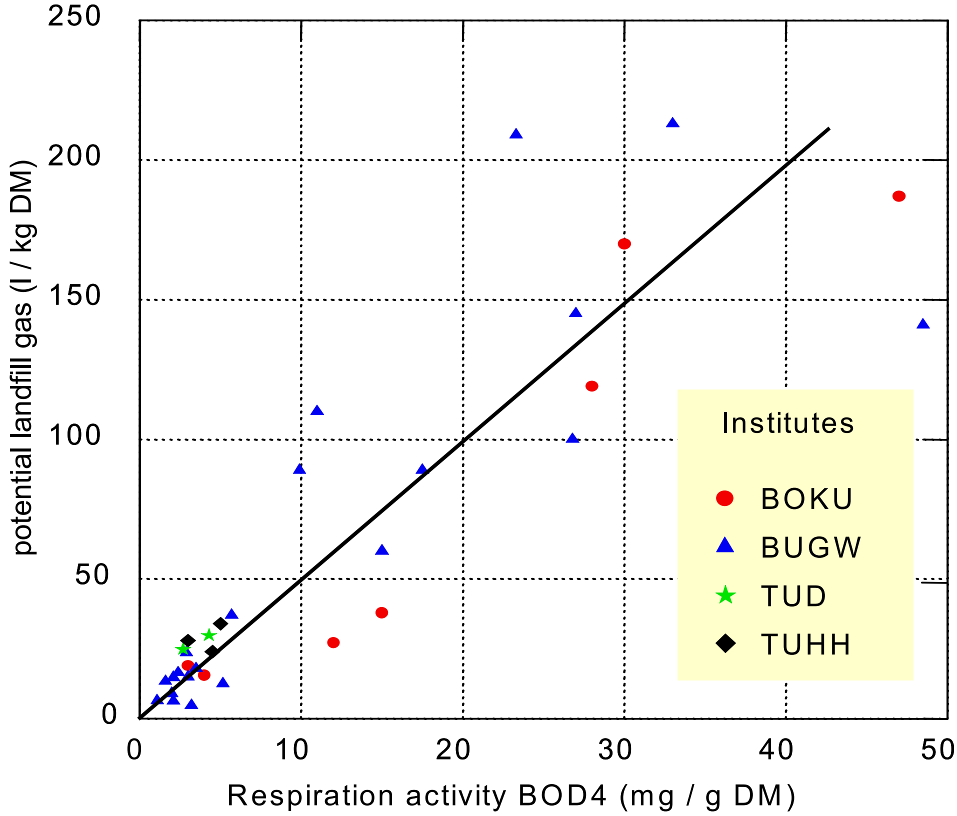

Figure 3 Correlation between BOD4 (AT4) and the potential of landfill gas formation, data from DANHAMER et al., 1998 (TUD); HÖRING and EHRIG, 1999 (BUGW); BINNER et al., 1997 BOKU) and HUPE et al. 1998, (TUHH)

There are also good correlations between the potential landfill gas and the parameter gas formation rate and between between AT4 and GB21.

AT4 and GB21 are both parameters that are based on microbiological activity. Toxic substances in the waste that can have a negative influence on the microbiological activity during the test and therefore result in an inaccurately low value. It is recommended, therefore, to introduce a second parameter, which doesn´t depend on the microbiological activity. The TOCeluate as a chemical parameter was found to be suitable, as it also correlates both with the landfill behaviour and the AT4.

6 Performance of Bio-Mechanical Waste Treatment within Europe

The EU Landfill Directive does not state any methods how to assess BMW of untreated waste or of bio-mechanically treated waste. Therefore it is the task of the member states to include respective requirements in their national laws implementing the EU Landfill Directive. Except for Germany and Austria so far no other national law contains respective requirements to assess the performance of bio-mechanically treated waste.

The following paper describes the existing methods and the targets set. Subsequently options for appropriate methods to assess the performance of MBT are derived.

6.1 Standards for MBT in Germany and Austria

Extensive and in depth research work has resulted in the acceptance of MBT in the German and Austrian landfill regulations. The net result is that the parameters and threshold values in Table 3 have been accepted by the regulating authorities in Germany for material processed by MBT systems.

Table 3 Threshold values for MBT wastes in Germany and Austria

	Germany	**Austria**
respiration activity (within 4 days)	< 5 mg/g DM	< 7 mg/g DM
gas formation rate within 21 days (GFR_{21})	< 20 l/kg DM	< 20 l/kg DM
total organic carbon in eluate (TOC_{eluate})	< 250 mg/l	-

As described above these parameters ensure an improvement of the landfill behaviour regarding landfill gas and leachate of more than 90 %. This is far more than what is required by the EU Landfill Directive. But the German and Austrian Governments claim that any country may set higher standards than the EU.

6.2 Limits according EU landfill directive requirements

The assessment approach applied in Germany and Austria is related to the most effective reduction of adverse environmental impacts caused by landfilling, i.e. the quality of the landfilled wastes in terms of potential to produce emissions when in the landfill. In both countries, specifications for the quality of the landfilled wastes are laid down and specific criteria for bio-mechanically treated wastes are included (see Table 3). In combination with landfill management measures, similar environmental protection levels are achieved as would be with the residues from incineration.

In order to comply with the EU Landfill Directive, which requires the operator to reduce the environmental impact of landfills with respect to landfill gas emissions and leachate quality by 65 %, the following threshold values for the reduction rates of BMW have to be met when using MBT.

Table 4 Recommendations of threshold values to meet the EU Landfill Directive for bio-mechanically treated waste

	threshold values to meet EU Landfill Directive
respiration activity (within 4 days)	< 10 mg /g DM
total organic carbon in eluate (TOC_{eluate})	< 500 mg/l

On the basis of test results, a decomposition time of 4 -6 weeks is required to reach the above values using a technical composting system (e.g. tunnel composting). The resulting degradation in the quantity of BMW is then approximately 50 %.

The proposed respiration activity threshold of 10 mg/g DM is in line with the 2nd draft of the EU working document "Biological treatment of Biowaste" (ANONYM, 2001).

Stabilisation to this level is also being used occasionally in Italy, France, Finland and Ireland.

6.3 Assessment approach UK

The UK decided to do things differently compared with Germany and Austria in two key ways:

- No threshold value but a sliding scale relating loss in mass and change in bio-stability to BMW diversion.
- Different measures of bio-stability to those used elsewhere, in particular BM100 and DR4 rather than gas formation rate (GB21) and static respiration Index SRI (AT4).

Based on the amount of waste arisings in the base year, the total amount of biodegradables has been determined. This approach does not actually specify the degree of degradability but only specify to what extent the organic content is of biogenic origin, e.g. textiles are only listed at 50 % because it is assumed that about 50 % of the textiles are cotton or linen and the other 50 % are plastic.

The total amount of BMW in the base year is then reduced according to the requirements of the EU landfill directive. This is shown in Figure 4 alongside the predicted increases in total waste and total BMW amounts.

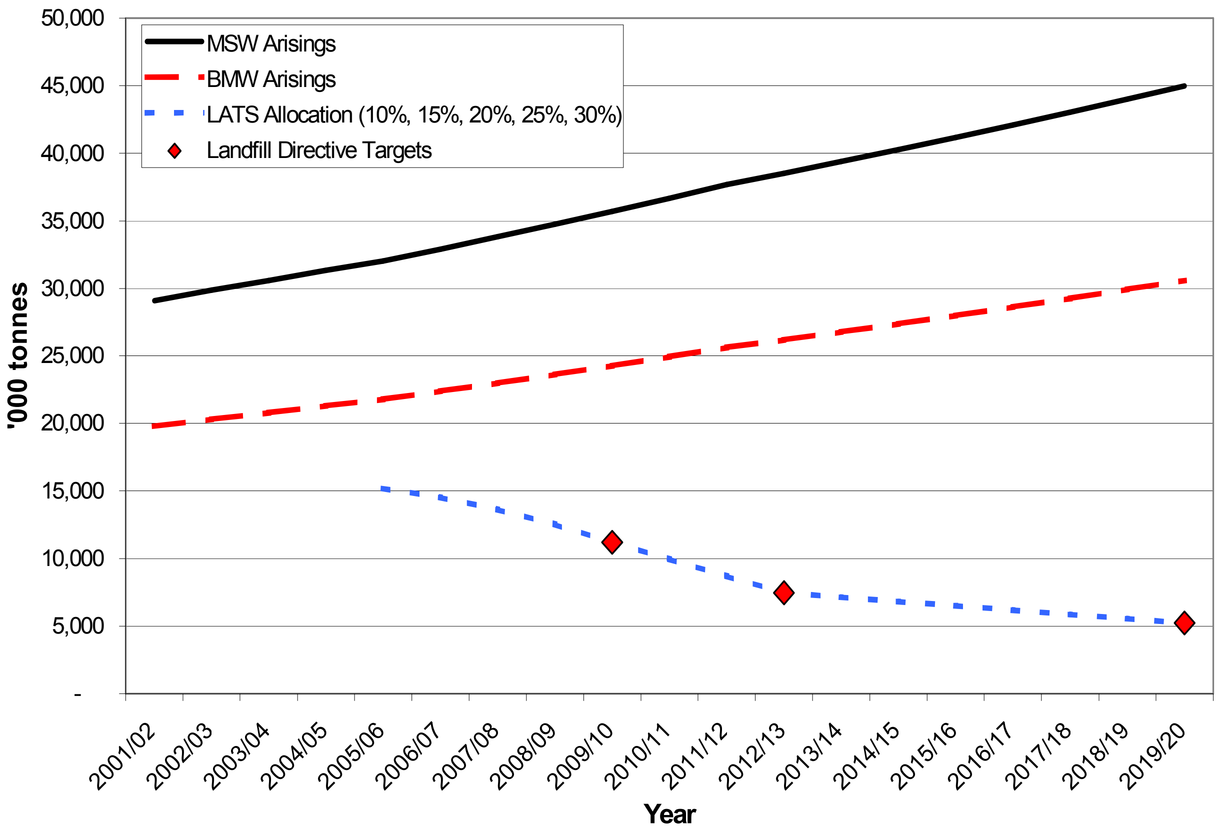

Figure 4 Total BMW landfill allowances for the UK

For the assessment of the performance of MBT in terms of the reduction of biodegradables a guidance document was developed by the Environment Agency (ENVIRONMENT AGENCY, 2005).

The BMW content has to be determined for the waste input entering the MBT and for the products of the process, e. g. RDF and recyclables. The mass loss through biodegradation has to be determined and any change in the moisture content has to be accounted for by adjusting the moisture content of the material which is destined for landfilling to the moisture content of the input into the MBT.

The adjusted mass loss is 100 % BMW and has to be subtracted from the BMW figure at the input to the MBT.

The biological degradability of the material at the beginning and end of the biological treatment has then to be determined and the relative reduction between these two test results is determined and used to further reduce the BMW mass remaining after the biological treatment.

The UK did its own research to determine which parameter is most suited for this purpose and selected a gas formation test over 100 days (BMP100) as the reference test. A dynamic respiration index test over 4 days (DR4) was selected as the most likely test to have a direct correlation with the BMP100 test and one which would provide a quicker result compared with the BMP100 test. A comparison of the German/Austrian static respiration test AT4 with the DR4 showed that the AT4 is vulnerable for fresh waste, but further tests showed that it may be possible to modify the AT4 test to mitigate this vulnerability (Godley et al.; 2005).

Figure 5 shows the change of BM100 during the course of a composting process. The pattern of the curve is similar to results from testing composting processes using SRI (see Figure 2).

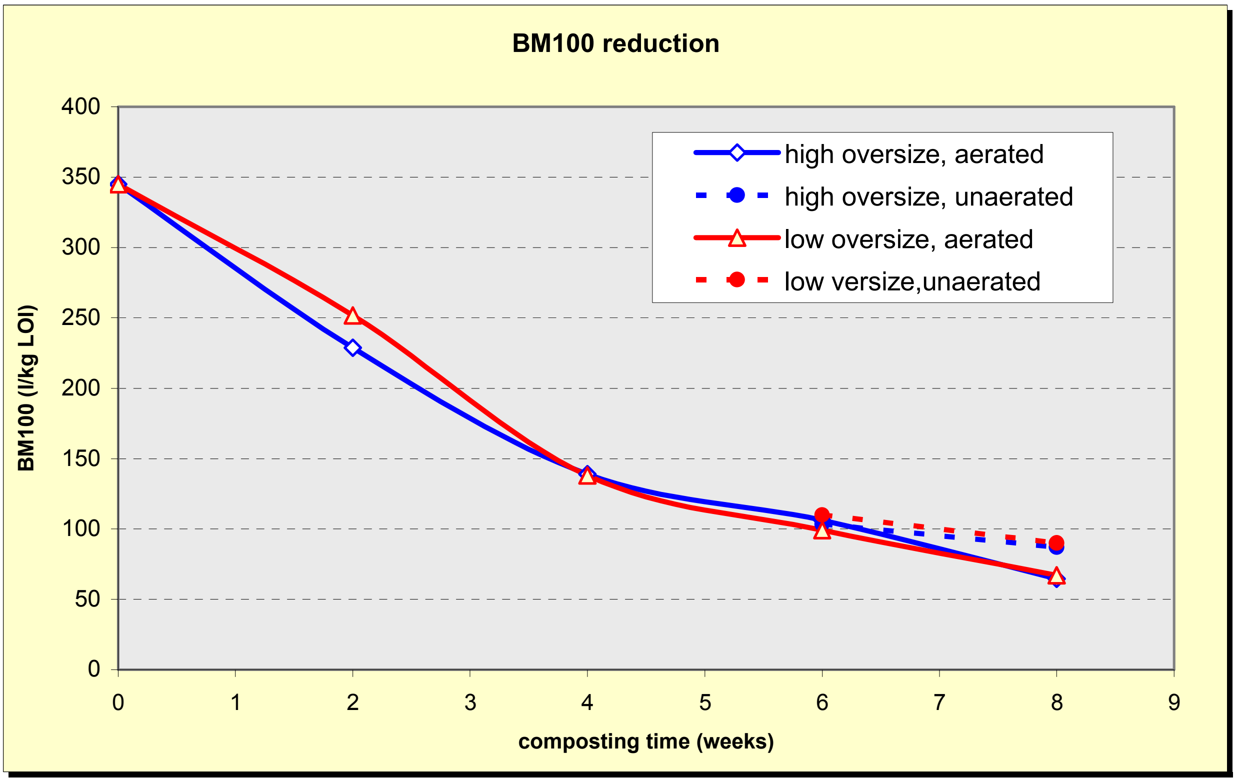

Figure 5 Change in bio-stability over time as assessed using BM100 using the New Earth Solutions technology treating residual municipal solid waste with higher and lower proportions of oversize material being subjected to biological treatment

Parallel tests show a fairly comparable pattern in terms of the relative change during the course of a composting process using SRI (AT4), DR4 and BM100.

This suggests a good correlation between the different parameters which allows to adapt the experience in terms of performance of MBT gathered in central Europe over a period of 15 years to the situation in the UK.

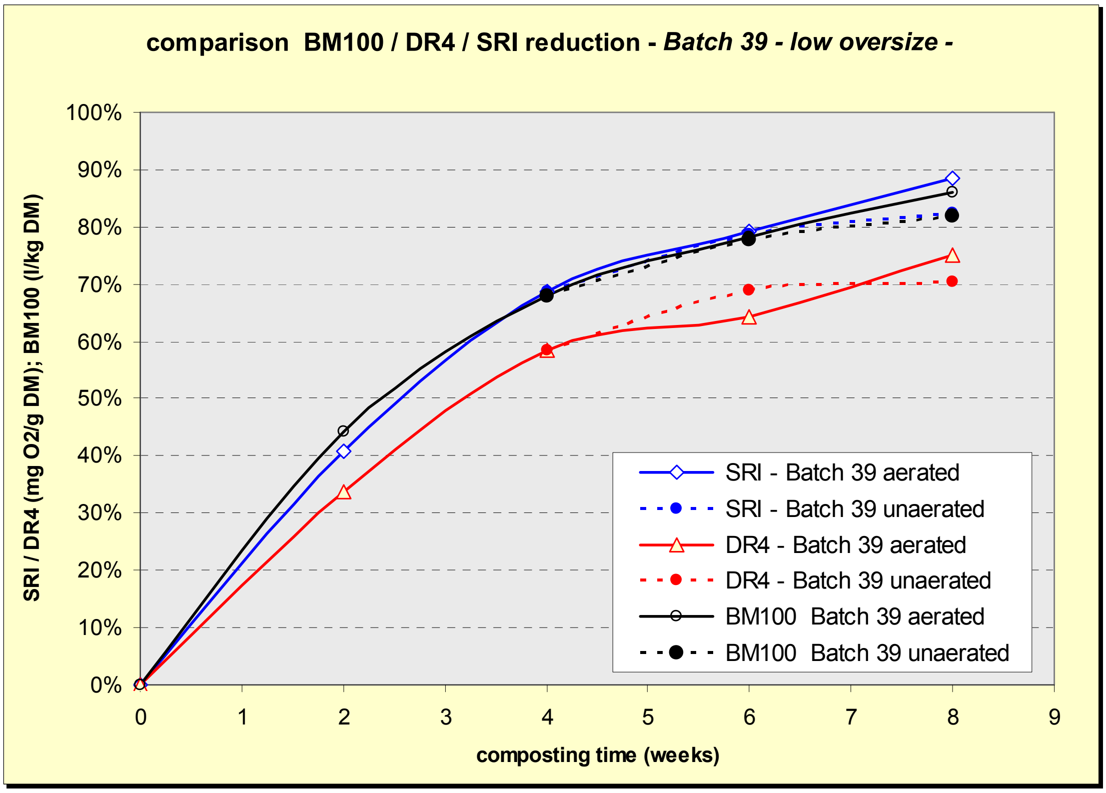

Figure 6 Change in bio-stability over time as assessed using BM100, DR4 and SRI using the New Earth Solutions technology treating residual municipal solid waste

6.4 Treatment time required to meet various targets

Based on extensive experience treatment periods required to meet the before discussed limits and approaches in terms of stabilisation can be specified. These figures are relevant for fairly technical, well designed facilities which have reference plants throughout Europe.

The UK approach does not provide a limit and hence is deemed to be flexible. As other requirements also apply, especially emission control, there might be limits triggered by these requirements.

	Respiration acitivity < 5 mg/g DM (German/Austrian limits)	**Respiration acitivity < 10 mg/g DM** (EC limit ??	**UK approach**
Composting	**8 – 16 weeks**	**5 – 8 weeks**	**flexible ?? > 4 weeks**
AD + composting	**2-3 weeks AD 4 – 10 weeks composting**	**2-3 weeks AD 2 – 5 weeks composting**	**flexible ?? 2-3 weeks AD > 1 week composting**

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