Basics of MBT and waste management system in Germany

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Abstract

The EC landfill directive demands the reduction of bio-degradable organic input into landfills. Separate collection of organic kitchen and garden waste for compost production is a first, useful and efficient step to reduce the organic landfill input. In areas, where the separate collection of organic waste (bio-waste) is already established or not possible, mechanical-biological (pre)treatment (MBP / MBT) is a way to reduce the organic landfill input remarkably. This article gives an overview over the basic elements of MBP-plants, material flow streams, biological degradation potential, necessary treatment duration, control parameters and costs.

Keywords

EC landfill directive, mechanical-biological waste treatment, organic matter, MBP, MBT, MBWT

1 Introduction

Five years after the EC landfill directive becomes effective in the EC member states, the landfilled amount of bio-degradable municipal waste has to be reduced 25% compared to the situation in 1995. After 8 years the reduction has to reach 50% and after 15 years finally 65%. Separate collection of organic kitchen and garden waste for compost production is a first, useful and efficient step to reduce the organic landfill input. In areas, where the separate collection of organic waste (bio-waste) is already established or not possible, mechanical-biological (pre)treatment (MBP / MBT) is a way to reduce the organic landfill input remarkably. This leads to a significant reduction of greenhouse gas emissions (in particular methane) from the landfill and a lower contamination of the landfill leachate. I also saves a lot of landfill volume because of higher emplacement density, degradation loss and extraction of metals an the high calorific fraction. In opposite to the composting of bio-waste, the biological treatment of residual waste in industrialised countries normally produces no fraction which can (or should) be used in agriculture. This is caused by the pollution of the residual waste by heavy metals and hazardous organic substances.

2 Waste management in Germany

2.1 Legal framework and waste management system

- 1986: Waste law prescribes, that avoiding of waste has to be preferred to recycling. Based on this, rules for product responsibility were created; e.g. used mineral oil can be returned priceless to the industry.
- 1991: Packaging ordinance: Producers and sellers are responsible for product packages and have to collect and recycle used packages.
- 1993: Landfill guideline with high standards for landfill construction and input (most still valid and equal or higher than EC-standards)
- 1996: Closed loop recycling management and waste law enforces avoiding and recycling of waste and opens the waste market partly for private enterprises.
- 2001: Waste storage ordinance (Abfallablagerungsverordnung AbfAblV) permitted MBT as an alternative to waste incineration.

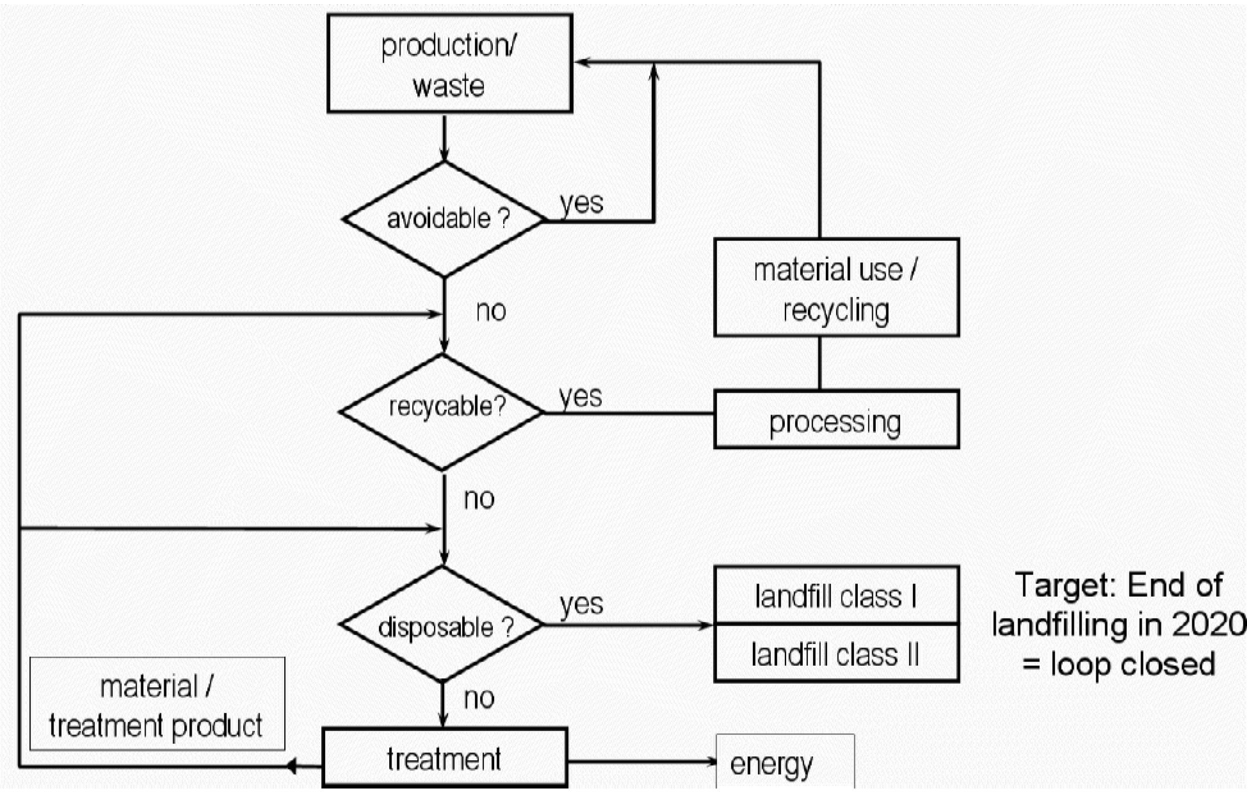


Figure 1 Waste management on the way to a closed loop recycling management in Germany

In dependence of the material or of it's original function (e.g. packages), different kinds of waste are separately collected:

- Paper (to be recycled)

- Glas (to be recycled)
- ”Bio-waste” (fruits, vegetables, plants and garden products...) 8 mio. Mg/a composted and used in agriculture
- Packing material (plastic boxes, plastic bottles, cans, ...) to be recycled or used for high calorific incineration
- ”The rest” (residual waste)

German Landfill classification:

- Class 0: Inert waste
- Class I: Quite inert municipal waste (e.g. some incineration ashes)
- Class II: Municipal waste
- Class III: Hazardous waste
- Class IV: Underground disposal site
  - Inert waste
  - Hazardous / nuclear waste in salt caverns

Waste has to meet chemical / biological and mechanical requirements specific to the class to be landfilled

Landfill (class 2) input since June 2005:

- Incineration ashes
- MBT - output
- Waste that meets legal standards without treatment

2.2 Residual waste treatment plants in Germany

The treatment of municipal waste in Germany is done as mechanical biological treatment and incineration. MBTs are usually located close to large landfills with huge vacant volumes and in rural areas, while incinerators are mainly used in dese populated urban areas. Additionally the preference for MBT or incineration has been significantly influenced by different political intentions in the federal states. Figure 2 shows the location of MBTs and incinerators in Germany.

MBT plants	Incineration plants
	

Figure 2 Location of MBTs (mainly installed after 2001) and incineration plants in Germany (source: www.asa-ev.de and www.itad.de)

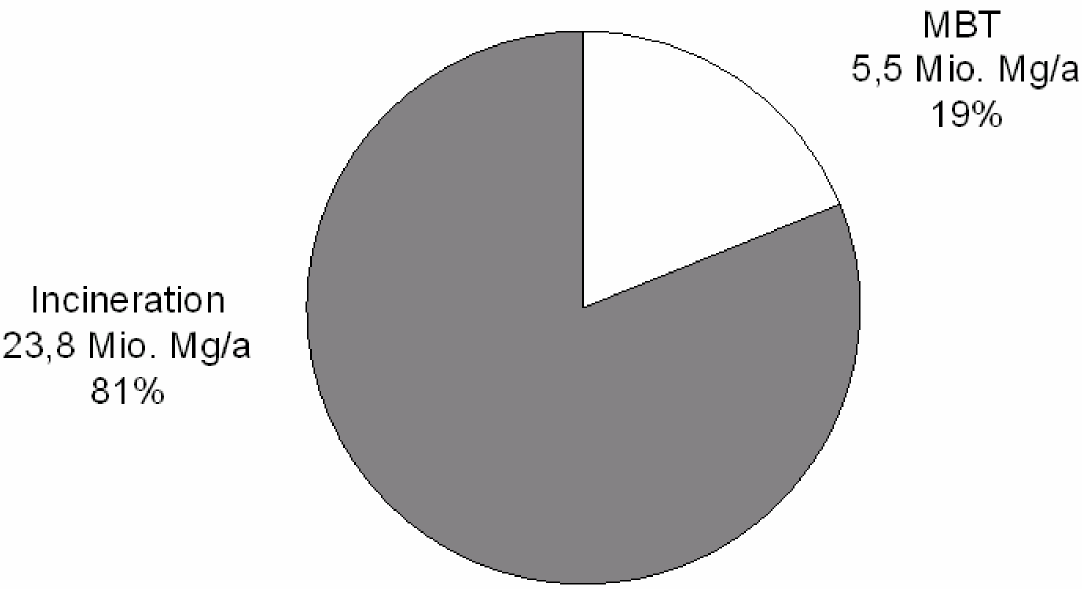


Figure 3 Total treatment capacity for municipal waste expected for 2010 in Germany (Kuehle-Weidemeier, 2003/5)

3 Kinds and components of MBT

3.1 MBT for waste drying

A special kind of MBT are plants, which are designed for a short and hot biological treatment just to dry the waste for later incineration and for sieving out usable (mineral) fractions. As these plants produce only a small amount of material which might be land-filled. Most components are similar to the MBTs prior to landfilling.

3.2 Components of MBT prior to landfilling

3.2.1 Mechanical treatment

3.2.1.1 Mechanical treatment before the biological treatment

The initial mechanical treatment has the following functions:

- Separation or conditioning (e.g. shreddering) of contraries. Method: Visual control and separation with polyp bucket.
- Separation of high calorific fractions for the use as refuse derived fuel (RDF). Method: Sieve (e.g. 80-150mm), sometimes air separation.
- Separation of waste components which can be recycled (e.g. metals). Method: Magnetic separator (Fe-metals) and sometimes eddy current separator (non-Fe-metals).
- Disintegration and homogenization of the waste for the biological treatment Method: Shredder / mill and mixing drum.

Depending on the local needs and legal demands, not all of these elements are used everywhere. Simple (in Germany older) MBTs just separate contraries to protect the machines and then shredder the waste. Commercial waste needs usually more mechanical processing than waste from private households.

3.2.1.2 Mechanical treatment after the biological treatment

Since May 2005 the upper calorific value and the TOC in the dry matter of landfilled waste are very strictly limited in Germany (similar in Austria). Usually the boundary values can be only achieved, if the waste gets a second mechanical treatment after the biological treatment. This is usually a sieving < 60 mm or smaller.

3.2.2 Biological treatment

3.2.2.1 Aerobic treatment

Low technical level

The most simple way of biological treatment are mainly passively aerated windrows under a roof, which are shifted from time to time, or static open air windrows, which use the dome aeration method, which is explained in Paar et al., 1999. The dome aeration windrows can be operated in open air directly on the landfill surface. The low technical processes need a long treatment time (e.g. 16-20 weeks) and therefore much space. Process control (e.g. moisture management) is difficult or at least not very precise, but it is possible to achieve a huge improvement of the landfilled waste at low investment costs. To run the windrows properly, experienced personal is needed.

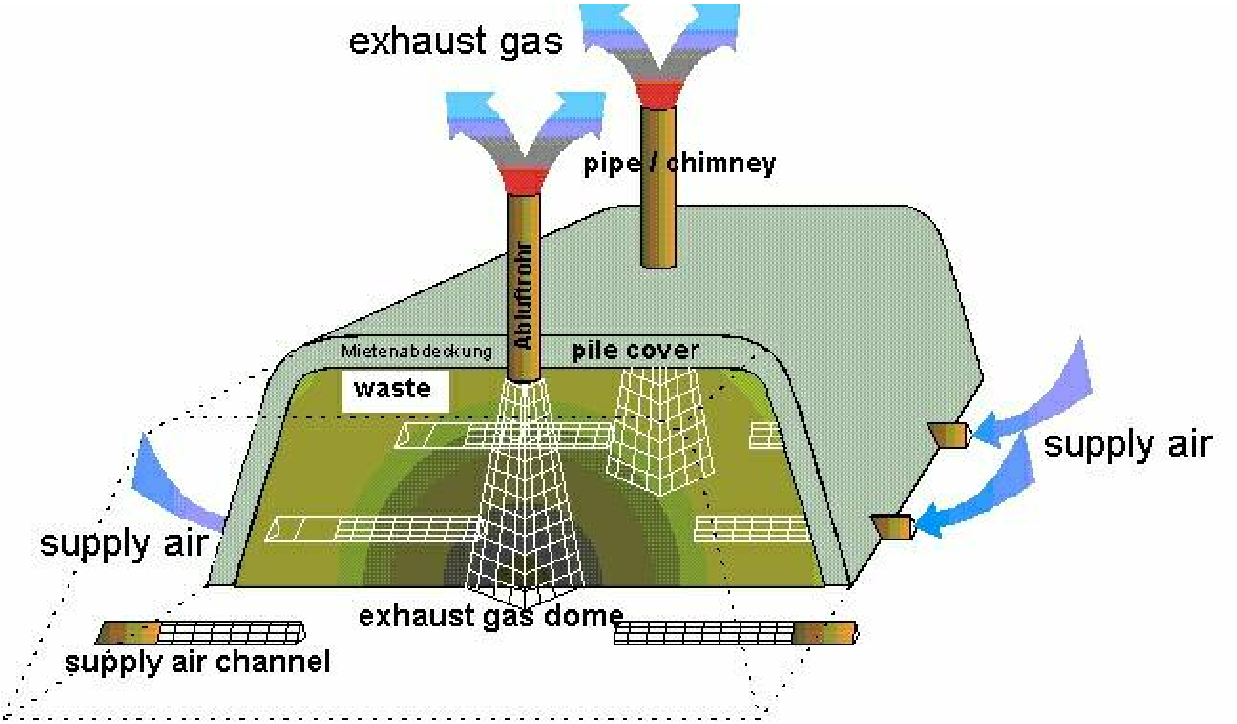


Figure 4 Dome aeration windrow (modified from Brummack et al., 2004)

High technical level

As future legal standards in Germany have high demands on gas emission control of MBT-plants and homogeneous "product" quality of the landfilled MBT-output, encapsulated MBTs with high technical effort will be the future there. The bio-logical processing is done in actively aerated, frequently shifted, large and plane windrows located in halls or in composting tunnels, which allow a better process and emission control and minimize the amount of exhaust gas that has to be treated.

The biological treatment can be subdivided in "intensive processing" and "post processing". The intensive processing is actively aerated and has a duration between 2 and 6 weeks, dependent on the MBT conception. The most of the biological degradation happens during the intensive processing, which releases also the most exhaust gas. Composting tunnels are especially suitable for the intensive processing. At the end of the intensive processing, an AT_4 of < 20 mg O_2 / g DM should be reached (see chapter 3).

In the post processing the metabolic rate is much lower, which allows to reduce the shifting intervals and the aeration. Triangular windrows might be only passively aerated, if they are shifted frequently (weekly, at least every second week). A hall is a good environment for the post processing.

3.2.2.2 Anaerobic treatment (digestion)

In some MBTs the aerobic treatment is combined with an anaerobic digestion, which produces methane gas for energy production. The digestion can be designed as

- full stream digestion or
- part stream digestion.

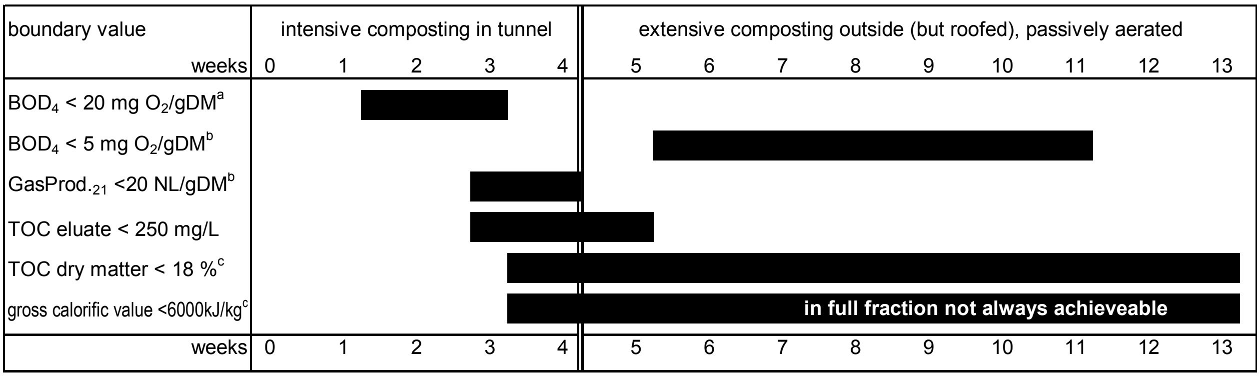
The full stream digestion processes the whole waste stream that is biologically treated. This results in high demands on the mechanical properties / stability of the digestion step and the dewatering at the end of the digestion. The advantage is the use of the whole methane production potential.

Part stream digestion includes just the fine fraction (e.g. < 40mm), while the (coarse) rest of the waste, which contains many anaerobically poorly degradable substances, goes directly in the aerobic treatment. After the digestion, the digested material is added to the aerobic treatment. A nameable dewatering is usually not necessary, as additional water is needed for the aerobic treatment of the undigested fraction.

To reach the German boundary values for landfilling and to prevent methane emissions, the digestion has always to be followed by an aerobic treatment step.

4 Boundary values and processing time

After May 2005 landfilling of untreated municipal waste will be prohibited in Germany. If mechanical-biological treatment (MBT / MBT) is used, drastic reductions of biological activity and energy content / total organic carbon have to be achieved (see Figure 1). The bio-degradation can be compared with the situation in a conventional landfill after 50 years or more. But in opposite to a conventional landfill, the degradation is homogeneous and there are no areas, which were not or only insufficiently affected by the degradation process. Furthermore, many substances can’t be well degradated under anaerobic conditions like in a landfill.



a) limit for not encapsulated treatment; b, c) can be alternatively used

Figure 5 Boundary values for landfilling of MBT-waste and range of the necessary biological treatment duration (0-150mm fraction) in a very well operated composting tunnel in a rural area (Schaumburg county)

Figure 5 shows the German standards for MBT-waste to be landfilled, and as an example the range of the necessary biological treatment time (results of 5 tests, each 25 Mg) in a very well operated aerobic tunnel treatment located in a rural area (SHG-county). In urban regions with more commercial waste, longer treatment times can be expected. Low technical level MBTs need much longer treatment times. Figure 6 gives an impression, how the AT_4 (BOD_4) decreased during two tests included in Figure 5, which had quite different start AT_4 values. The most of the degradation is already done within the first four weeks. After this time, harder degradable substances are left, which need much more time for degradation.

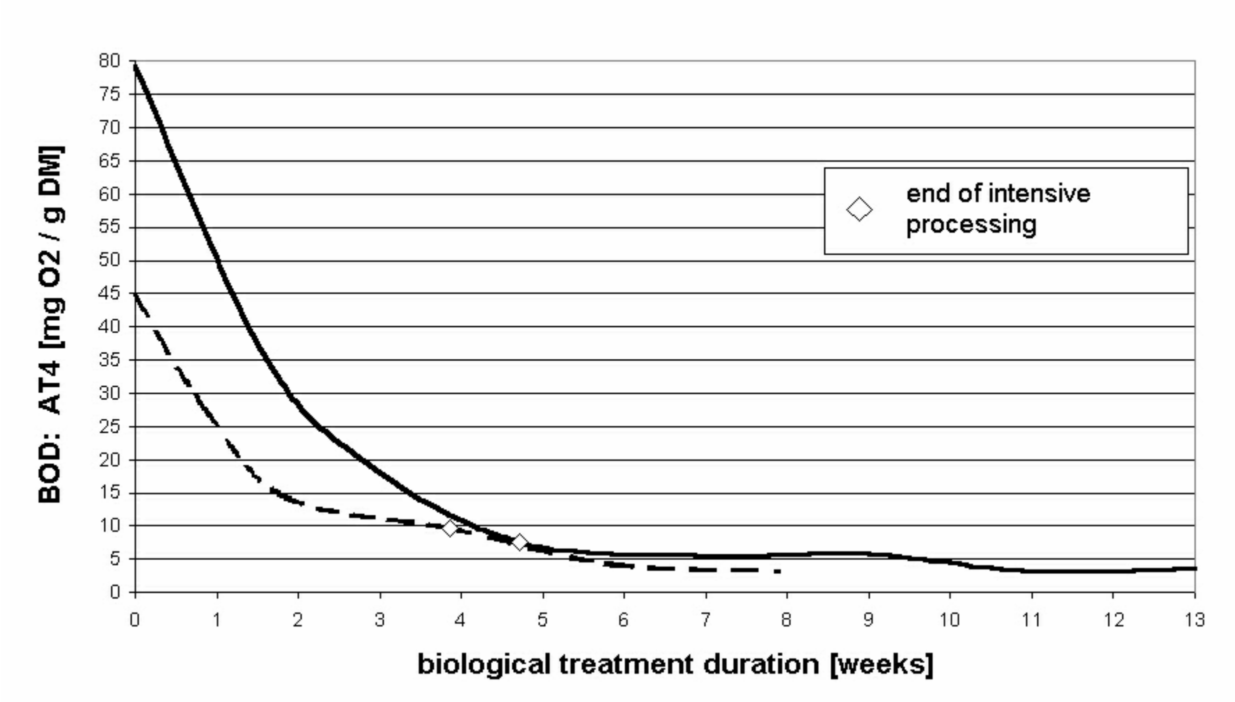


Figure 6 Degradation (reduction of the AT_4) of two different waste batches under optimal conditions as described in Figure 5

As there are many control parameters and some of them can be alternatively used, it is of interest, how the ratio between comparable parameters is and if there are other parameters, which can be easier determinated and are meaningful too. Table 1 and Figure 7 show the relations found at the tests documented in Figure 5 and Figure 6. At other locations with other waste compositions there are differences, as the comparison with the values from Fricke et al., 1999 shows (Table 1, right column).

Table 1 Relation between several control parameters found at the tests in Schaumburg county

compared parameters	relation (all analyses)	standard deviation, absolute	standard deviation, relative	samples	Relation Fricke et al., 1999
Ho, wf [kJ/kg] / IL [%DM]	205	23,7	11,5 %	62	
TOC [%TS] / IL [%DM]	0,52	0,048	9,2 %	62	
Ho, wf [kJ/kg] / Hu, wf [kJ/kg]	1,07	0,006	0,5 %	23	
Ho, wf [kJ/kg] / TOC [%DM]	398	33,0	8,3 %	61	
AT_4[mgO_2/gDM] / GB_{21}[NL/kg]	0,48	0,77	159,1 %	55	0,37
$COD_{El.}$ [mg/L] / $TOC_{El.}$ [mg/L]	2,87	0,28	9,9 %	79	2,6 +50mg/L
$TOC_{El.}$ [mg/L] / AT_4[mgO_2/gDM]	20,9	11,78	56,3 %	78	60

*TOC in the Eluate is no legal alternative parameter for AT_4 DM = dry matter, GB = gas prod.
IL = ignition loss; wf = waterfree; Ho = gross (upper) calorific value; Hu = lower cal. value

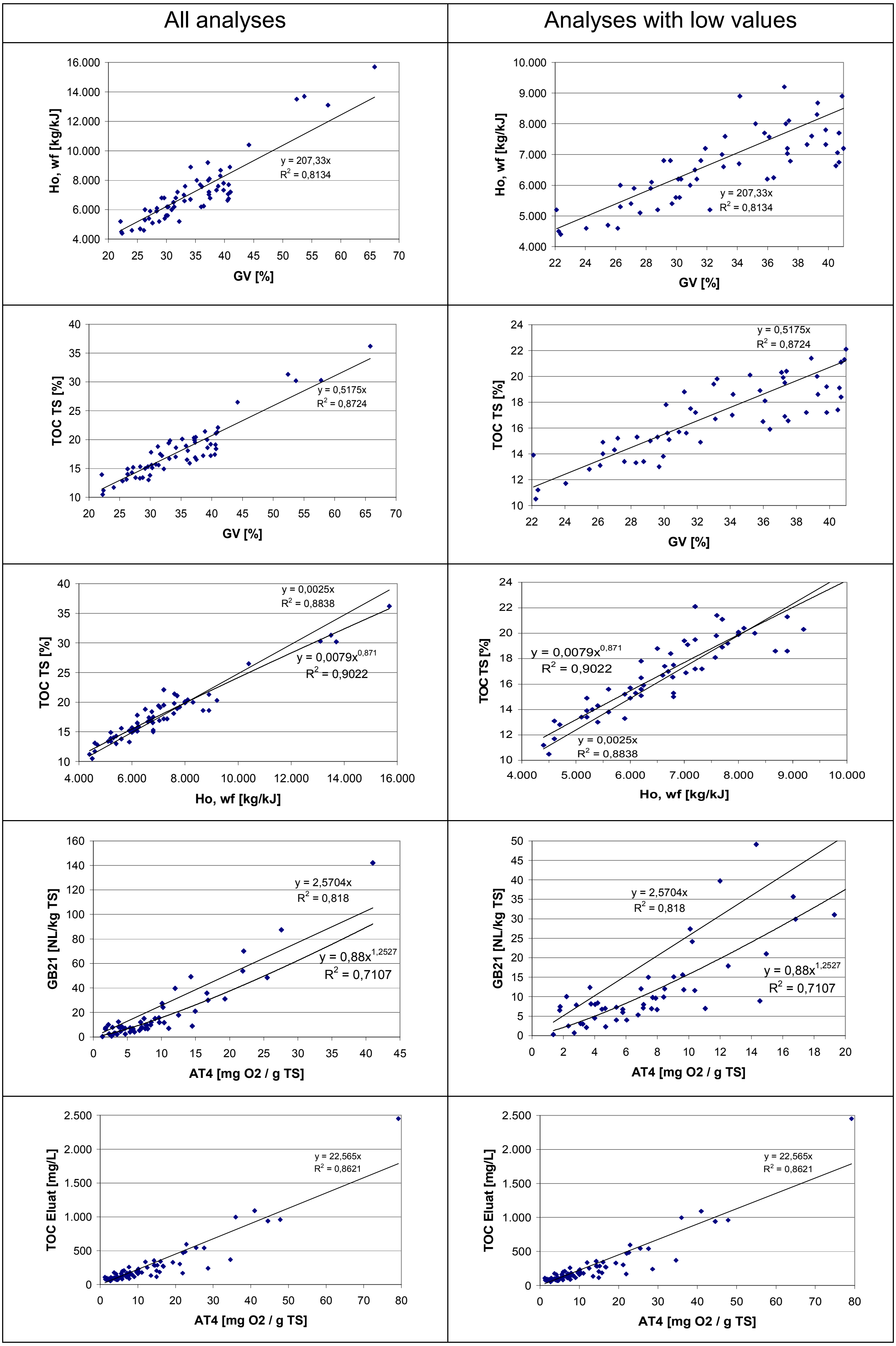


Figure 7 Parameter correlations in tests at Schaumburg county (Kuehle-Weidemeier, 2003/5)

5 Material flow streams

Different MBT conceptions, treatment aims and waste origins are leading to significant differences between the material flow streams from different MBTs. Figure 8 shows the material balance of recent MBT-plants and some pilot tests. The differences can be explained as follows:

MBT Erbenschwang was mainly built to reduce odour emissions. The separation of a high calorific fraction had no large importance and the output is already landfilled at an AT_4 of about 20 mg O_2 / g DM. This both results in a very high amount of landfilled material. The huge landfilled fraction at MBT Lueneburg is based on the fact, that (before 2005) one third of the MBT-input is just shreddered and directly landfilled (not on the MBT-landfill sector). MBT Wiefels has a quite coarse input sieve and can integrate a large part of the whole waste stream in the landfilled fraction. The degradation loss of 27% is not plausible and might have its reason in mistakes in the original mass balance. These MBTs do not produce an output, which is compliant to the future German standards.

Only the tests and the balance of the MBT Bassum (only temporarily) consider an output sieving after the biological treatment to fulfill the new standards for calorific value / TOCDM. Accordingly they have a different mass balance. The MBT Bassum uses a quite fine sieve of 80mm for the input. In connection with a high content of commercial waste this explains the huge contingent of the high calorific fraction. The comparatively high amount of landfilled material in the tests at Schaumburg is based on the mechanical treatment. The input sieve had a diameter of 150mm. The fraction 80-150mm was shreddered and added to the fine fraction. This allowed to include more waste components in the biological treatment, which is important for the huge amount of nappies (diapers) for example.

The amount of contraries in not correctly integrated in the balances. At the moment, contraries of huge sizes go directly to the landfill and do not reach the MBT input. After May 2005, when most of those materials can't be landfilled untreated, is has to be expected, that 10-20 mass-% of the waste are contraries, which need extra mechanical treatment with very heavy duty machines.

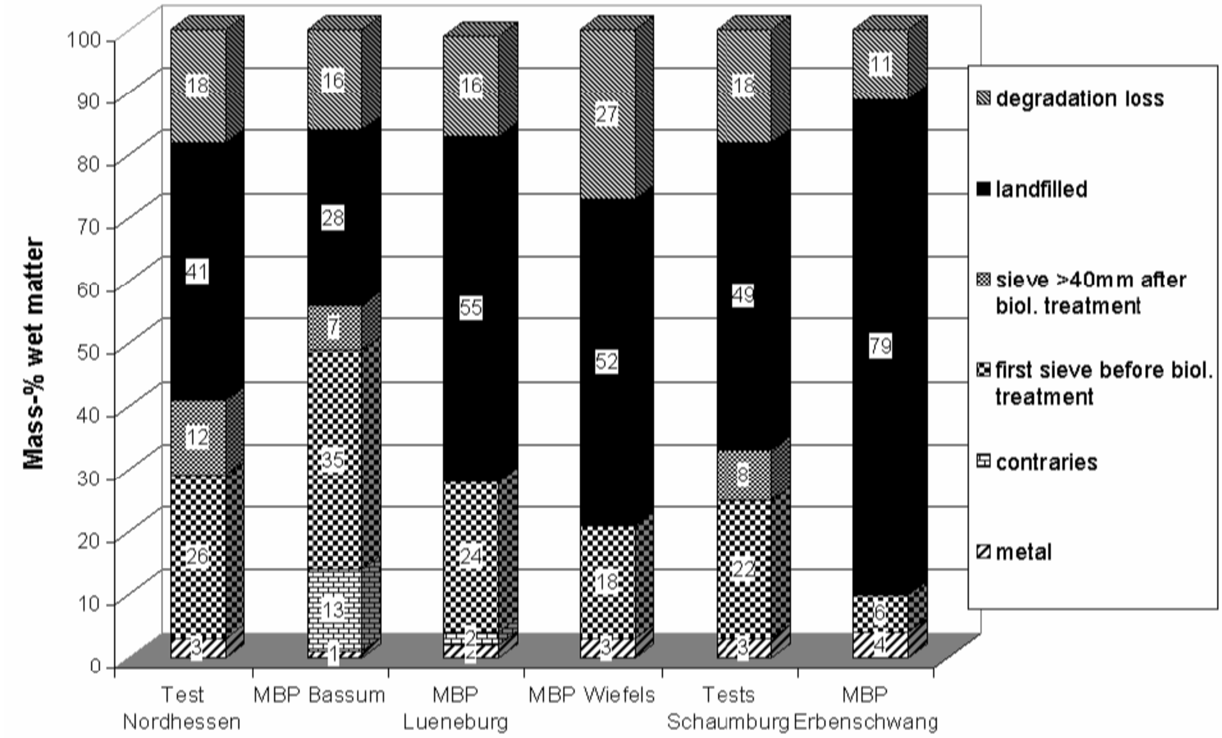


Figure 8 Material flow from different MBTs (Kuehle-Weidemeier, 2003/5)

Data source: MBT Bassum, Lüneburg, Wiefels: Doedens et. al., 2000; MBT Erbenschwang: Hertl et. al., 2001; Test Nordhessen: Doedens, Kuehle-Weidemeier, 2000; Tests Schaumburg: Doedens, Kuehle-Weidemeier, 2001

6 Costs

The costs for MBT-treatment compliant to the future German standards will be 40-60 Euro / Mg MBT-input. This does not include the costs for landfilling etc. Low technical solutions allow costs about 10-20 Euro / Mg. These figures include investment and operation costs.

7 Conclusion

Mechanical-biological treatment of residual waste is able to reduce the degradable organic input to landfills significantly and to reduce the demand for landfill volume. Depending on the used technique, treatment durations between 6 and 20 weeks are needed to achieve good results. The specific costs are between 10 and 60 Euro / Mg depending on the technique, legal demands and the local costs for labour, area, energy etc.

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