

MECHANICAL-BIOLOGICAL TREATMENT (MBP) OF MUNICIPAL SOLID WASTE AS AN EFFICIENT WAY TO REDUCE ORGANIC INPUT INTO LANDFILLS

Dr. Matthias Kuehle-Weidemeier

Wasteconsult international, Robert-Koch-Str. 48 b, 30853 Langenhagen, Germany, www.wasteconsult.de, info@wasteconsult.de

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.

Key words: 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 (new) 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 (particularly methane) from the landfill and a lower contamination of the landfill leachate. In opposite to the composting of bio-waste, the biological treatment of residual waste in industrialized 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. KINDS AND COMPONENTS OF MBP

2.1 MBP for waste drying

A special kind of MBP are plants, which are designed for a short and hot biological treatment just to dry the waste for later incineration and for sieving out unusable (mineral) fractions. As these plants produce only a small amount of material which might be landfilled, they are no subject of this publication.

2.2 MBP prior to landfilling and it's components

2.2.1 Mechanical treatment

2.2.1.1 Mechanical treatment before the biological treatment

The initial mechanical treatment has the following functions:

- Separation or conditioning (e.g. shredding) 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) MBPs just separate contraries to protect the machines and then shredder the waste. Commercial waste needs usually more mechanical processing than waste from private households.

2.2.1.2 Mechanical treatment after the biological treatment

After May 2005 the upper calorific value and the TOC in the dry matter of landfilled waste is very strictly limited in Germany (similar in Austria). It seems that 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.

2.2.2 Biological treatment

2.2.2.1 Aerobic treatment

Low technical level

The most simple way of biological treatment are mainly passively aerated piles under a roof, which are shifted from time to time, or static open air piles, which use the dome aeration method, which is explained in Paar et al., 1999. The dome aeration piles 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 investments. To run the piles properly, experienced personal is needed.

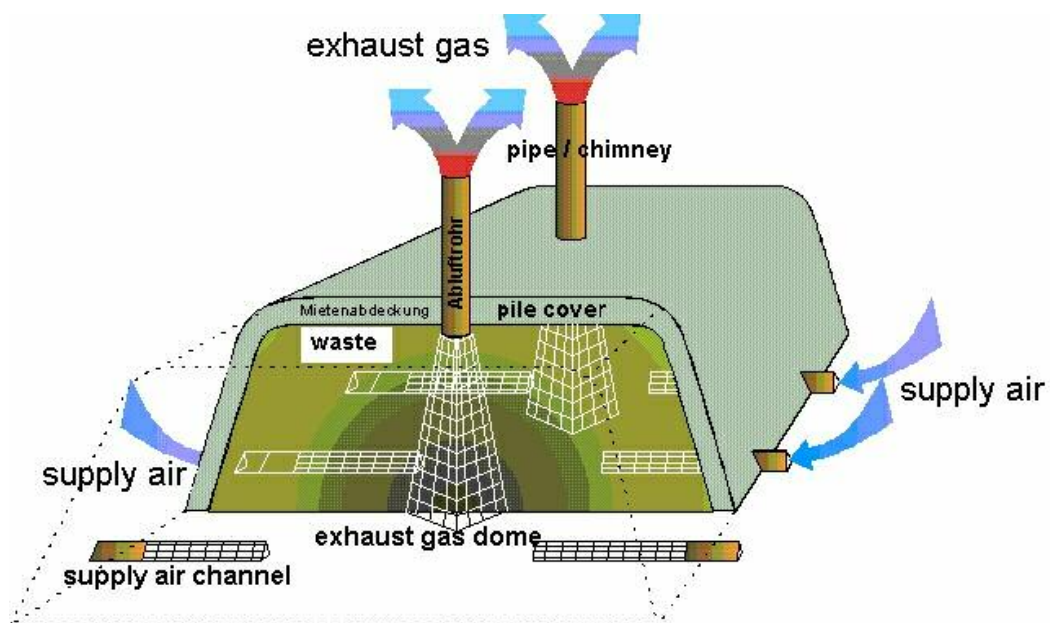


Figure 1: Dome aeration pile (modified from Brummack et al., 2004)

High technical level

As future legal standards in Germany have high demands on gas emission control of MBP-plants and homogene "product" quality of the landfilled MBP-output, encapsulated MBPs with high technical effort will be the future there. The biological processing is done in actively aerated, frequently shifted, large and plane piles lo-

cated 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 MBP 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 $< 20 \text{ mg O}_2 / \text{g DM}$ 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 piles 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.

2.2.2.2 Anaerobic treatment (digestion)

In some MBPs 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. $< 40\text{mm}$), 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.

3. Boundary values and processing time

After May 2005 landfilling of untreated municipal waste will be prohibited in Germany. If mechanical-biological treatment (MBP / 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 degraded under anaerobic conditions like in a landfill.

boundary value	intensive composting in tunnel					extensive composting outside (but roofed), passively aerated									
	weeks	0	1	2	3	4	5	6	7	8	9	10	11	12	13
BOD ₄ < 20 mg O ₂ /gDM ^a			■	■	■										
BOD ₄ < 5 mg O ₂ /gDM ^b							■	■	■	■	■	■	■	■	■
GasProd. ₂₁ < 20 NL/gDM ^b					■	■									
TOC eluate < 250 mg/L					■	■	■	■	■						
TOC dry matter < 18 % ^c					■	■	■	■	■	■	■	■	■	■	■
gross calorific value < 6000kJ/kg ^c					■	■	■	■	■	■	■	■	■	■	■
							in full fraction not always achievable								
weeks		0	1	2	3	4	5	6	7	8	9	10	11	12	13

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

Figure 2: Boundary values for landfilling of MBP-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 2 shows the future German standards for MBP-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 MBPs need much longer treatment times. Figure 3 gives an impression, how the AT₄ (BOD₄) decreased during two tests included in Figure 2, which had quite different start AT₄ 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.

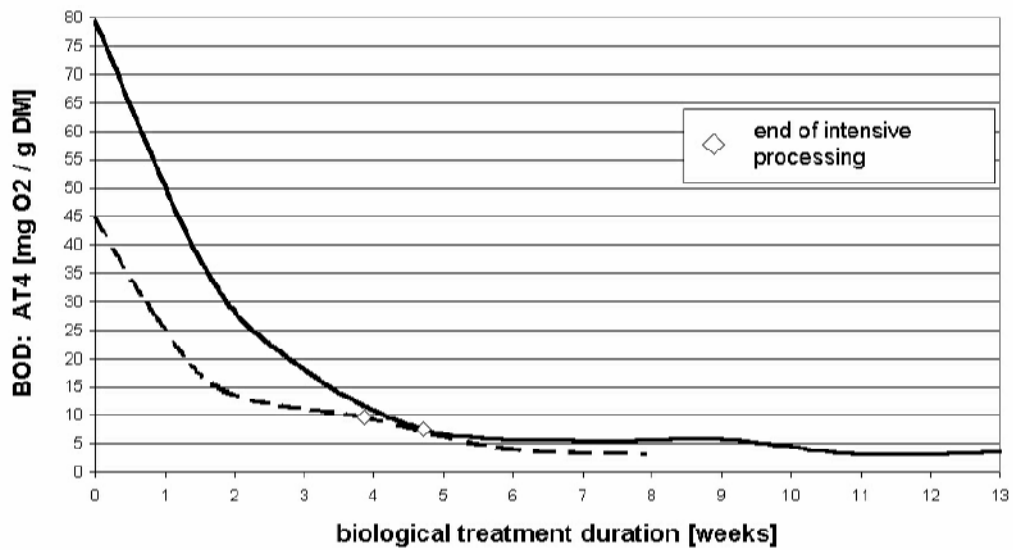


Figure 3: Degradation (reduction of the AT₄) of two different waste batches under optimal conditions as described in Figure 2.

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 determined and are meaningful too. Table 1 and Figure 4 show the relations found at the tests documented in Figure 2 and 3. 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 analys.)	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 AT₄ DM = dry matter, GB = gas prod. IL = ignition loss; wf = waterfree; Ho = gross (upper) calorific value; Hu = lower cal. value

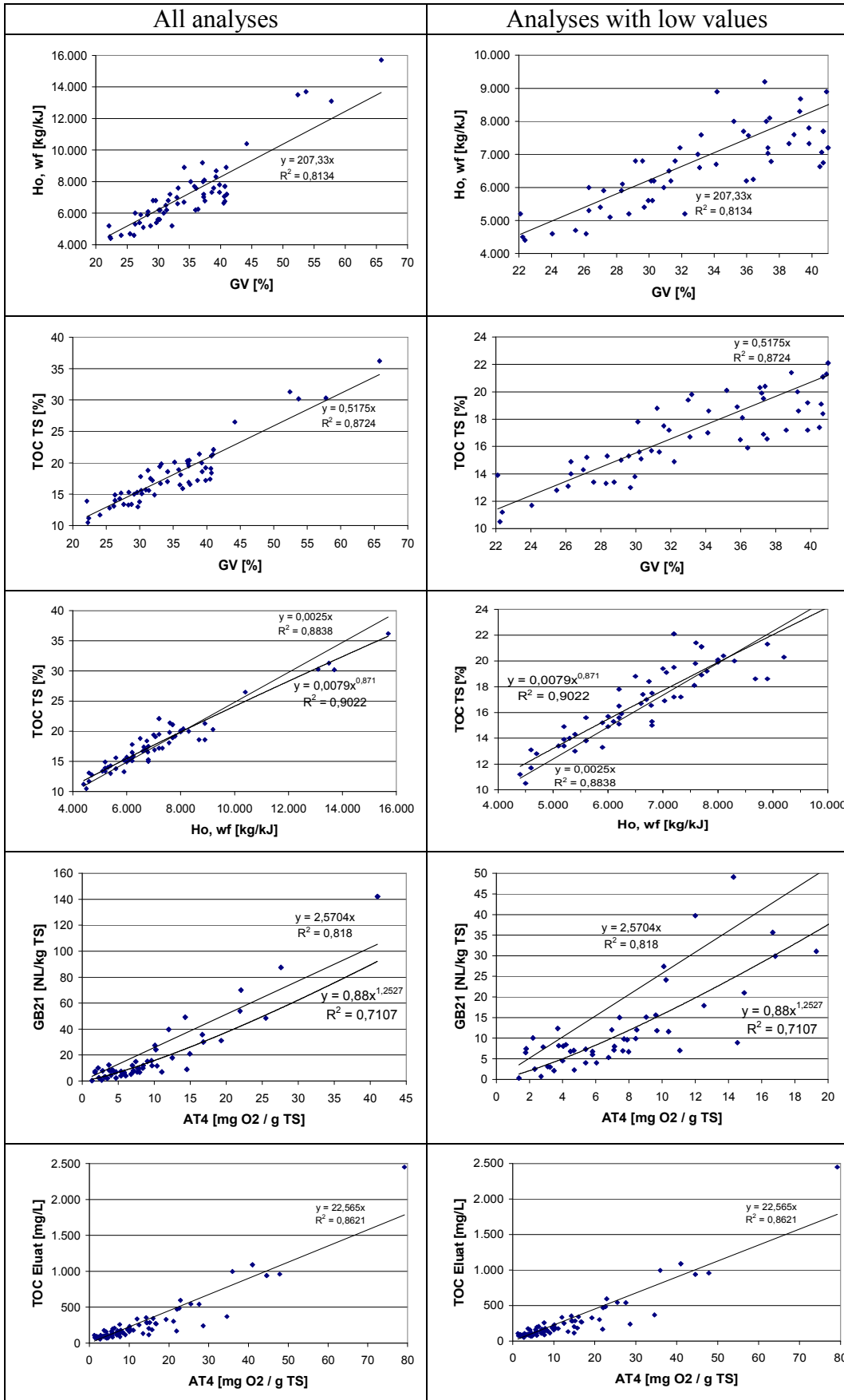


Figure 4: Parameter correlations in the tests at Schaumburg county

3. Material flow streams

Different MBP conceptions, treatment aims and waste origins are leading to significant differences between the material flow streams from different MBPs. Figure 5 shows the material balance of recent MBP-plants and some pilot tests. The differences can be explained as follows:

MBP Erbenschwang was mainly built to reduce odor emissions. The separation of a high calorific fraction had no large importance and the output is already landfilled at an AT_4 of about $20 \text{ mg O}_2 / \text{g DM}$. This both results in a very high amount of landfilled material. The huge landfilled fraction at MBP Lueneburg is based on the fact, that (before 2005) one third of the MBP-input is just shredded and directly landfilled (not on the MBP-landfill sector). MBP 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 MBPs do not produce an output, which is compliant to the future German standards.

Only the tests and the balance of the MBP Bassum (only temporarily) consider an output sieving after the biological treatment to fulfill the new standards for calorific value / TOC_{DM} . Accordingly they have a different mass balance. The MBP 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 shredded 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 is not correctly integrated in the balances. At the moment, contraries of huge sizes go directly to the landfill and do not reach the MBP input. After May 2005, when most of those materials can't be landfilled untreated, it has to be expected, that 10-20 mass-% of the waste are contraries, which need extra mechanical treatment with very heavy duty machines.

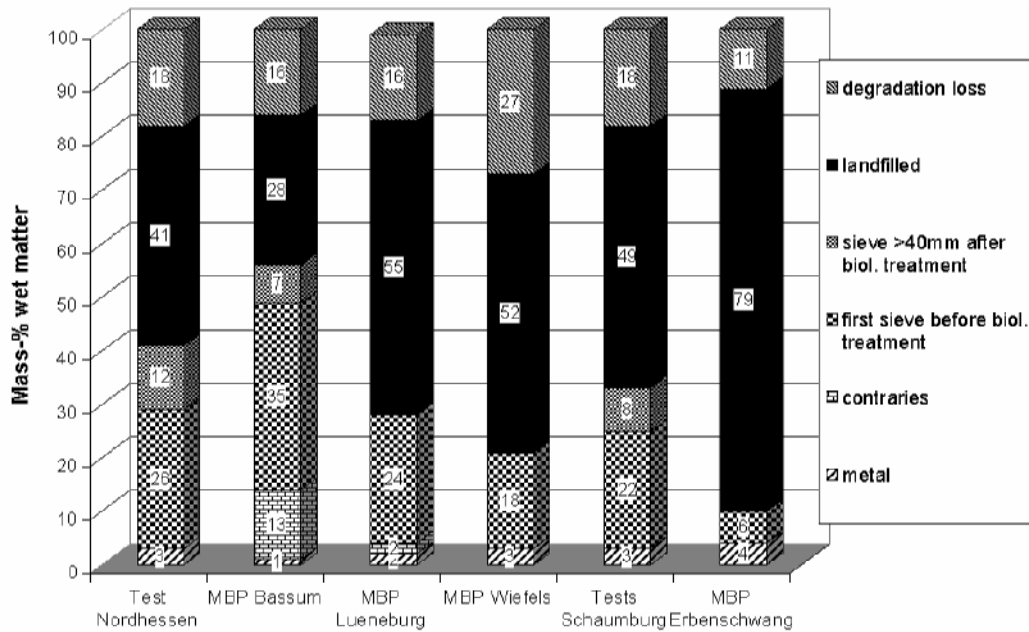


Figure 5: Material flow from different MBPs (Kuehle-Weidemeier, 2003)

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

3. Costs

The costs for MBP-treatment compliant to the future German standards will be 40-60 Euro / Mg MBP-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.

3. Conclusion

Mechanical-biological treatment of residual waste is able to reduce the degradable organic input to landfills significantly. 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.

REFERENCES

All not extra cited figures and tables are from Kuehle-Weidemeier (2003)

- Brummack, J.; Polster, A. (2004): Das Dombelueftungsverfahren – ein vielseitig einsetzbares Belueftungsverfahren für offene Rottemieten auch nach 2005. In: Kuehle-Weidemeier, M., 2004: Abfallforschungstage 2004. Auf dem Weg in eine nachhaltige Abfallwirtschaft. Tagungsband. Cuvillier Verlag Goettingen. ISBN 3-86537-121-3. Pages 194-210.
- Doedens, H.; von Felde, D.; Cuhls, C.; Ketelsen, K.; Bröker, E.; Fehre, E.; Giebel, B. (2000): Wissenschaftliche Begleitung der drei großtechnischen Demonstrationsanlagen zur mechanisch-biologischen Vorbehandlung von Restabfällen in Niedersachsen. Endbericht. Institut für Siedlungswasserwirtschaft u. Abfalltechnik der Universität Hannover, Hannover und Ingenieurbüro für Abfallwirtschaft und Entsorgung, Hannover.
- Doedens, H; Kuehle-Weidemeier, M. (2000): MBA-Pilotversuch und Ermittlung grundlegender Abfalleigenschaften im Landkreis Waldeck-Frankenberg. Institut für Siedlungswasserwirtschaft und Abfalltechnik der Universität Hannover. Unpublished.
- Doedens, H; Kuehle-Weidemeier, M. (2001): MBA-Pilotversuche mit Abfaellen aus dem LK Schaumburg, Wissenschaftliche Begleitung Versuche 1-3. Ergebnisbericht. By order of Abfallwirtschaft Landkreis Schaumburg. Unpublished.
- Doedens, H; Kuehle-Weidemeier, M. (2003): MBA-Pilotversuche mit Abfaellen aus dem LK Schaumburg, Wissenschaftliche Begleitung Versuche 4 und 5. Ergebnisbericht. By order of Abfallwirtschaft Landkreis Schaumburg. Unpublished.
- Fricke, K.; Müller, W.; Bartetzko, C; Einz-mann, U.; Franke, J.; Heckenkamp, G.; Kell-ner-Aschenbrenner, K.; Kölbl, R.; Mellies, R.; Niesar, M.; Wallmann, R.; Zipfel, H. (1999): Stabilisierung von Restmüll durch mechanisch-biologische Behandlung und Auswirkungen auf die Deponierung. Endbericht BMBF-Verbundvorhaben biologische Abfallbehandlung, Teilvorhaben 2.1. IGW Ingenieurgemeinschaft Witzenhausen.
- Hertl, M.; Huber, W. et al. (2001): Wissenschaftliche Begleitung der MBA Erbenschwang. Bayrisches Institut fuer angewandte Umweltforschung und – technik – BifA GmbH, Augsburg, in co-operation with Abfallwirtschaft & Umwelttechnik Ingenieurgesellschaft bRmbH, Augsburg. Unpublished.
- Kuehle-Weidemeier, M. (2003): Bedarf, Konstruktionsgrundlagen und Betrieb von Deponien fuer mechanisch – biologisch behandelte Siedlungsabfaelle. Veroeffentlichungen des Institutes fuer Siedlungswasserwirtschaft und Abfalltechnik der Universitaet Hannover, Band 127. ISBN 3-921421-57-8.
- Paar, S.; Brummack, J.; Gemende, B. (1999): Advantages of Dome Aeration in Mechanical-Biological Waste Treatment. 7th International Waste Management and Landfill Symposium, Cagliari, 4.-8. October 1999.