Bio-mechanical treatment (BMT) of residual household waste after separate collection of recyclable fractions

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1 Definitions

Biomechanical treatment (BMT) of waste:

- composting or anaerobic treatment of biowaste (separately collected greend yard waste, park waste, kitchen waste etc.); products: compost or biogas
- sewage sludge composting
- composting or anaerobic treatment of residual household waste after separate collection of recyclable fractions; products: residues for disposal and/or a high caloric fraction for incineration resp. co-combustion in industrial plants.

Separate collection of recyclable fractions in Germany:

- glass
- paper/cardboard
- textiles
- food and non-food packages with the „green point", especially plastic and plastic compounds (e.g. paper/cardboard/plastic; metal/plastic)

<u>Remaining fraction:</u>

- wet, low calorific value (below 11000 kJ/kg)
- treatment pathways:
    - dumping (without pre-treatment allowed until june 1, 2005)
    - thermal treatment: about 52 MSWI plants in Germany, high emission protection standard (17th BImSchV)
    - BMT: about 10 plants with different technological level and concept (in FRG)

<u>Problem:</u>

Since june 1, 2000, disposal is only permitted on landfills and in a way that in consequence these landfills will need less caring during and after operation

- landfills
- instruments (under others:
    - reduction of trickling water amount
    - reduction of trickling water contamination
    - reduction of gas emission (amount and contamination)

if some parameters are kept in

- solid waste
- eluate (elution) of the waste.

Keeping these parameters (heavy metals, organic content) in solid waste and eluate can only be achieved after thermal treatment; waste and eluate after BMT cannot keep the limits for organic residues.

Table 1: Eluate concentrations of heavy metals and TOC in wastes after BMT

	arsenic (µg/l)	cadmium (µg/l)	mercury (µg/l)	TOC (mg/l)	ref.
Eluate after 10 months until 2 years extensive aerobic treatment (household waste)	< 25	< 0,5 - 2	< 1	11 - 79	(1)
eluate from residual household waste/sewage sludge, digested	10 - 38	< 1	0,6	**161 - 318**	(2)
eluate from digested material, diff. digestion periods	< 0,5 - 56	< 5	0,7 - 9	**590 - 1.387**	(3)
eluate from dried stabilized waste from digestion boxes (average)	10	2 - 10	4	**611 - > 1.000**	(4)
limit for disposal (class II)	≤ 500	≤ 100	≤ 20	100	

So at the moment many counties and operators think about new treatment aims, especially for the high caloric fraction, or hope that the parameter limiting organic residues in the TASI will be changed either by rising the TOC in the solid substance and in the eluate or by accepting alternative methods for measuring organic carbon like the fermetation test or the respiration activity test. Tomorrow, Mr. Bröker will tell you more about this.

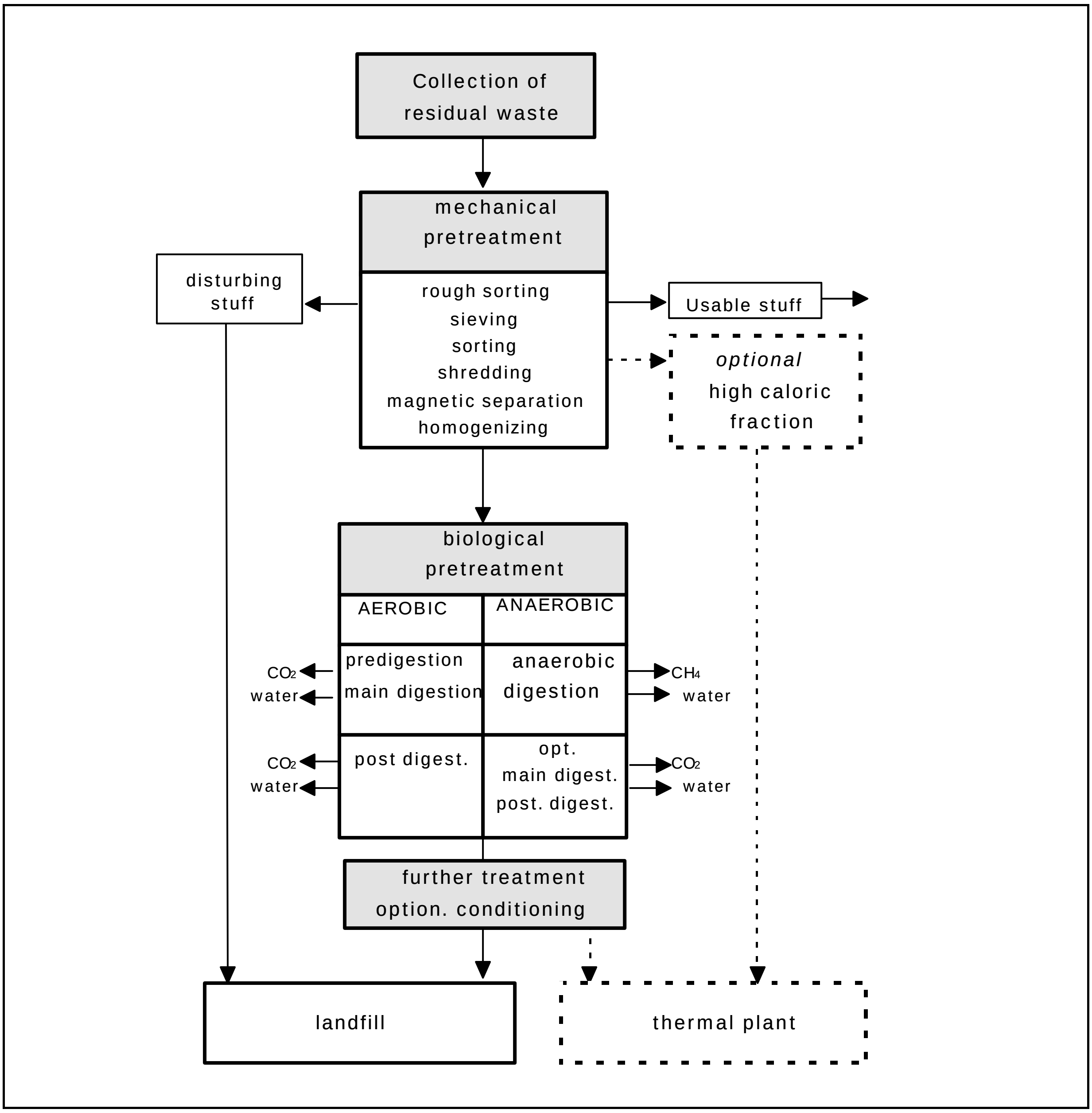
Let us now have a look on technological levels and concepts.

2 Technological levels and concepts of BMT

There are different concepts of BMT plants in Germany, referring to the preferred waste strategy:

- BMT followed by landfill
- BMT followed by thermal treatment in a MSWI
- BMT followed by so-called energetic recycling in industrial plants; within BMT the waste is splitted into at least two fractions: one with low and one with high calorific value.

Figure 1: Idealized concept of a BMT plant



We can distinguish three different strategies:

- low level BMT
- low-level BMT with improved mechanical techniques
- BMT for complete digestion.

2.1 Low-level BMT

Low-level BMT for residual waste treatment have a very low technical standard. The waste is treated mechanically (shredding etc.), then put on composting piles; the pile basis is often built by EURO-pallets or similar bulk rubbish, which supports aeration („chimney draft process“). The piles are often built in a special area of an old landfill that is still in operation. After 2 to 12 months the piles are compressed without taking up the digested material, and an new layer is built upon the compressed one. This is called an **extensive** biological digestion. In most cases, there is no emission control or analysis of the digested material. These plants will not be permitted after june 1, 2005.

Figure 2: MBA Oldenburg *(mba-ol-s.doc)*

Low-level BMT with improved mechanical techniques work similar to the plants mentioned above.

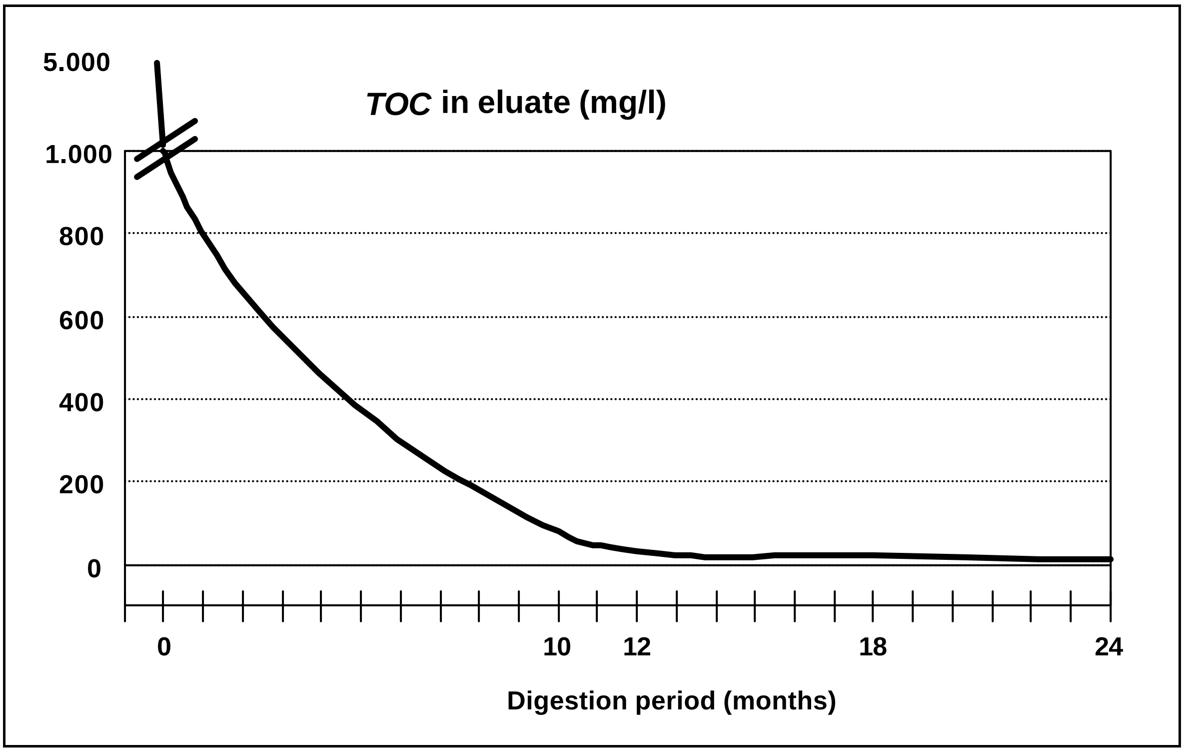
Figure 3: MBA Kirchberg *(mba-kirc.doc)*

Table 2: German BMT plants with **extensive biological** digestion in operation, 1996 (5)

Area, city/name	location	owner / managed by	land
Low-level-MBT			
Oldenburg	landfill Osternburg	City of Oldenburg	Lower Saxony
Schwaebisch Hall	landfill Hasenbuehl	Schwaebisch Hall county	Baden-Wuerttemberg
Wilhelmshaven	landfill Wilhelmshaven-North	City of Wilhelmshaven	Lower Saxony
Low-level- MBT with improved mechanical treatment			
Bad Kreuznach	landfill Meisenheim	waste management company of the Bad Kreuznach county	Rhineland-Palatinate
Kirchberg	central landfill Kirchberg	waste management company of the Rhein-Hunsrueck county	Rhineland-Palatinate

The follwing figure shows the digestion kinetics of extensive biological digestion, using data for the „chimney draft process“ first described by Spillmann and Collins (6).

Figure 4: Digestion kinetics of extensive BMT (idealized, following data by Stegmann)



The actual permitteld level of 100 mg TOC/l eluate can perhapts be kept after a treatment period of at least 10 months.

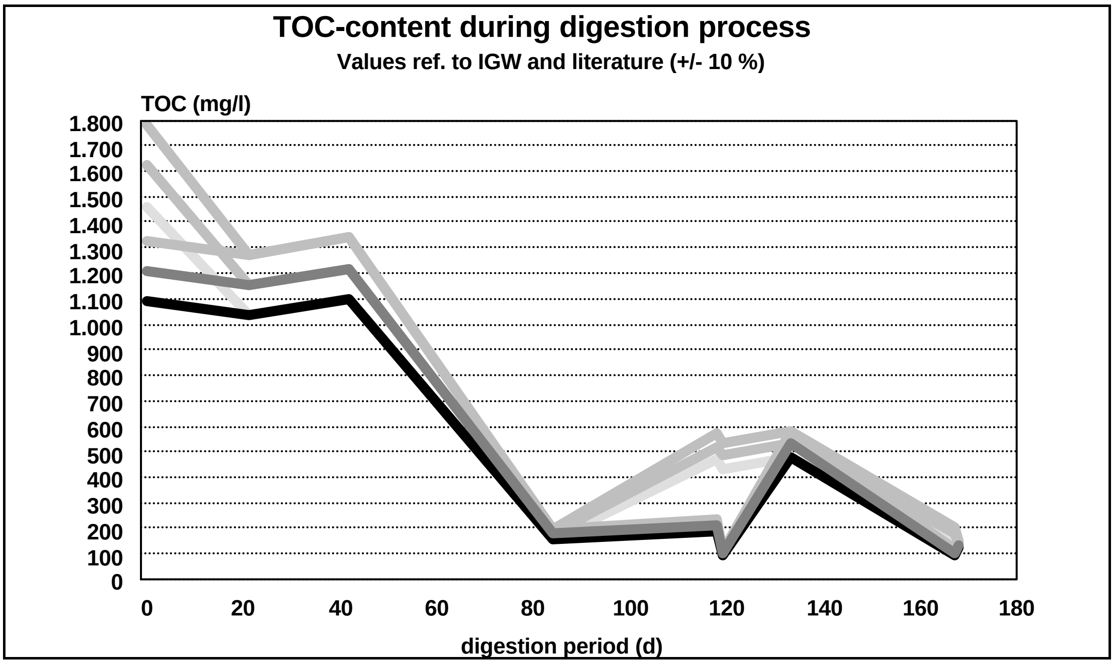
2.2 Improved BMT

A lot of new BMT plants show a lot of technical improvements compared to low-level plants. The biological step is a controlled and partly (main digestion steps) closed technique with some kind of air pollution outlet control.

Some BMT plants try to reduce organic content in the waste as far as possible (final aerobic digestion) by **intensive biological treatment**. Improved techniques try to optimize mainly the steps of shredding, homogenizing and adjusting humidity during digestion. The residues are disposed at a landfill (BMT followed by landfill).

Here, too, the problem is the organic burden of the remaining residues, especially the eluate. The following figure shows the TOC contents of eluate depending on treatment duration. It can be seen, that at least 4 months of intensive treatment are necessary to keep the TASI-limit of 100 mg TOC/l eluate. This is a cost factor, too.

Figure 5: TOC-content of eluate during digestion process (intensive biological treatement) data by IGW and literature (± 10 %)



Obviously, even intensive biological treatment cannot guarantee to keep the TASI-limits within a (from a financial point of view) reasonable time period.

Within the last few years, a new concept has entered the stage of looking for the fittest waste management strategy: the so-called **waste splitting**. Here the high caloric fraction of the waste is separated from the fraction with a low caloric value by sieving; this is possible because the high caloric pieces often have greater dimensions referring to their weight. The high caloric fraction is given to MSWI or, in more often cases, to co-combustion in industrial plants, the other fraction is digested by intensive BMT and then disposed (so-called partial digestion).

Waste splitting leads to other „products“ as the BMT of the whole waste, as in the fraction that fell through the sieve the biodegradable organic fraction is concentrated. Digestion (even intensive BMT) of this fraction can lead to residues that keep the limits for organic burden in solid phase or eluate only after very, very long treatment periods.

Table 3: BMT with intensive biological treatment

Area, city/name	location	owner / managed by	land
Dueren	landfill Horm	Dueren landfill company DDG, Huertgenwald	Northrhine-Westfalia
Lueneburg	central landfill Lueneburg	waste management company of Lueneburg Ltd. (GfA)	Lower Saxony
County of Bad Toelz - Wolfrats-hausen	Quarzbichl	Recovery and recycling company Ltd. (Wertstoffgewin-nungs- und Verwertungs-GmbH (WGV)), Eurasburg	Bavaria
County of Weilheim-Schongau	waste management center Erben-schwang	GEA company for building the zur waste management center Erbenschwang	Bavaria

Figure 6: MBA Dueren (final digestion) *(mba-dür.doc)*

Figure 7: MBA Lueneburg (splitting) *(mba-lüne.doc)*

3 Problems of BMT

BMT plants face a lot of problems. Some of them will be discussed here.

3.1 Emissions and emission control

A great problem of MBA plants are emissions. One is of course the odor emission. Most improved or „technical“ MBAs clean part of ist exhaust gas (mainly of the intensive digestion process) by so-called biofilters. Biofilters can help to clear the odor emission, but have to operate under optimized conditions and need sufficient maintenance.

In the past, biofilters were regarded as effective countemeasure against emission of organic substances, too.

3.1.1 Organic substances

BMT gas emissions contain a lot of organic substances, and some heavy metals like mercury and cadmium, too. The concentration can reach considerable amounts and come into the range of the permitted organic parameters (class I to III) of the technical guideline for clean air (TA Luft).

The following table shows some data collected from different BMT plants and pilot scale tests.

Table 4: BMT Lueneburg: Results of raw gas analysis (single measurement) (Cuhls et al.)

Class	substance	TA Luft Anhang E (1996)	raw gas after air scrubber (µg/m³)
FCKW	R 11	class III	28,3
	R 12	class III	0,2
	R 21	-	1,0
	R 22	-	2,2
	R 113	-	1,3
	R 114	-	10,2
CKW	Dichlormethan	class I	14,5
	Trichlormethan	class I	0,9
	Tetrachlorkohlenstoff	class I	0,5
	1,2-Dichlorethan	Nr. 2.3	0,6
	1,1,1-Trichlorethan	class II	6,5
	1,1,2-Trichlorethan	class I	25,6
	Tetrachlorethen	class I	4,3
aromates	Benzol	Nr. 2.3	2,6
	Toluol	class II	39,2
	Ethylbenzol	class II	29,1
	p-, m-Xylol	class II	124,4
	o-Xylol	class II	25,3
Σ org. C	TOC	-	25,0 mg/m³

At the moment, emissions are a matter of research, and the more research is performed, the more new substances are detected in BMT raw gas. Here is the chromatogram of such a sample (raw air, BMT Quarzbichl, after intensive biological treatment).

Figure 8 *(Chromatogramm.doc and chromatogram, data.xls)*

Therefore, the question arises, wheather biofilters or bioscrubbers are best available technique for BMT emission control or not.

Table 5: Raw and clean gas burdens of biofilters (Kranichstein) after aerobic treatment of a residual waste/sewage sludge mix

parameter		∅ raw gas	clean gas 6.4.	clean gas 13.4.	raw vs. clean gas 6.4.	raw vs. clean gas 13.4.	reduction 6.4.	reduction 13.4.
Hg	µg/m³	0,13	0,058	0,089	0,45	0,68	55%	32%
Cd	µg/m³	0,16	0,158	0,215	0,99	1,34	1%	- 34%
Benzol	mg/m³	0,11	0,24	0,04	2,18	0,36	- 118%	64%
Toluol	mg/m³	3,25	5,65	1,29	1,74	0,40	- 74%	60%
Xylol	mg/m³	2,77	6,79	2,39	2,45	0,86	- 145%	14%
Ethylbenzol	mg/m³	1,35	2,32	0,47	1,72	0,35	- 72%	65%
Chlorbenzole	ng/m³	679,5	406	360	0,60	0,53	40%	47%
Chlorphenole	ng/m³	123	36	14	0,29	0,11	71%	89%
PCB (DIN)	ng/m³	56,6	2,05	n.b.	0,04	n.b.	96%	n.b.
EPA-PAK	µg/m³	7,05	2,3	2,68	0,33	0,38	67%	62%
PCDD/F TE	pg/m³	6,17	7,02	6,67	1,14	1,08	- 14%	- 8%
TOC	ppm	650	750	120	1,15	0,18	- 15%	82%

It is obvious that the filter effectiveness varied to a great extent.

Table 6: BMT Lueneburg: Effectiveness of biofilter (7)

Class	substance	TA Luft Anhang E (1996)	Effectiveness of biofilter
FCKW	R 11	class III	70 %
	R 12	class III	> 50 %
	R 21	-	20 %
	R 22	-	86 %
	R 113	-	54 %
	R 114	-	70 %
CKW	Dichlormethan	class I	63 %
	Trichlormethan	class I	33 %
	Tetrachlorkohlenstoff	class I	40 %
	1,2-Dichlorethan	Nr. 2.3	66 %
	1,1,1-Trichlorethan	class II	40 %
	1,1,2-Trichlorethan	class I	62 %
	Tetrachlorethen	class I	65 %
aromates	Benzol	Nr. 2.3	62 %
	Toluol	class II	58 %
	Ethylbenzol	class II	34 %
	p-, m-Xylol	class II	48 %
	o-Xylol	class II	41 %
Σ org. C	TOC	-	60 %

At the moment, it can be concluded that there is no guarantee that biofilters are a reliable and reproducable technique for air pollution control of BMT emissions. Here further tests are needed.

Improved filter techniques alternative to or in combination with biofilters are

- adsorption (on e.g. activated carbon)
- thermal treatment
- catalytic oxidation
- chemical treatment (e.g. with ozone).

These techniques are available, but cause higher costs. Their suitability for cleaning BMT gas is very good (= b.a.t.) for adsorption, thermal treatment and catalytic oxidation, but not for chemical treatment (at the moment).

3.2 Occupational health protection

Many problems concernig occupational health in composting, sorting and recycling plants have been reported from Sweden and Denmark. Especially processing steps with intensive moving or shredding of the waste, which contains a lot of microbes and microbial products with a high potential of causing allergic reactions, pose a threat to occupational health. The symptoms are exogen-allergic alveolits/organic dust toxic syndrome (EAA/ODTS), infections and other illnesses. Some lands like Autria or Thuringia aks for special occupational protection measures:

- no mechanical sorting of residual waste
- encapsulate dust emitting steps (shredding etc.)
- no manual turnover of the compost piles
- black-white-sytems for separation of contaminated and uncontaminated areas
- no permanent working places in exposed areas like digestion hall or else
- breathing masks for working in sensitive areas.

Furthermore, clean air parameters have to be kept by technical aeration systems:

- 10 000 microbes (colony forming units) per m^3
- 0,1 µg endotoxins/m^3.

Manual sorting of residual waste cannot be regarded as b.a.t., because there are better technical solutions. In addition, the results of recovering valuable materials are small, and removal of disturbing stuff can be performed by other methods (automatized).

4 Pespectives of BMT

I want to close my report with some statements concerning chances and risks of BMT:

1. BMT is **no super-weapon** for solving municipal waste problems. Low-level BMT have no perspectives here in germany after 2005, though some counties try to get an exceptional permission for prolonged using of their old plants (e.g. Hannover).
2. Good BMT needs good techniques, in treatment as well in emission control; and this is a cost factor. E.g. simple biofilters are not sufficient for solving emission problems. Advanced filter techniques (like e.g. activated carbon) will lead to rising investment and operation costs.
3. BMT is - especially in Germany - no longer an <u>alternative</u> to the unloved MSWI, but is a preliminary step or a supplement for MSWI or co-combustion in industial plants, which often have lower emission standards. If you want to use the BMT as preliminary step before co-combustion in industrial plants, make sure, that this is really the better solution even under ecological (and not only uner economical) aspects. I think, Mr. Bröker will tomorrow talk about this special problem, too.
4. What's BMT's perspective: BMT is a suitable element for **evolutionary development** to modern integrated waste management, that means: start with a BMT in order to stop disposal of untreated wastes, and then use the next years for performing a contest on the waste market for finding the ideal solution (economically and ecologically) for your county or city. This can be a MSWI, a combination of BMT and MSWI or something else; let the contest of systems give the answer to your problem, don't wear blinkers.

Thank you.

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