Mechanical Biological Treatment and its role in Europe

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1 Introduction

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. In order to minimise environmental nuisance for odour, fly and noise nuisance, these facilities are 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.

2 MBT Systems

MBT is often referred to 3 main types of MBT system that can process the organic element of the waste stream:

- Aerobic stabilisation
- Anaerobic digestion
- Biological drying

What is common to all types is that there is a front end mechanical processing of the waste. This will be through some form of shredding and additional treatment to separate the materials from organic to non organic materials. The differences are in the type of the biological treatment (aerobic or anaerobic) and the treatment target (stabilisation or drying to foster subsequent separation stages).

2.1 Aerobic Stabilisation

The key target of this approach is to stabilise the waste and hence reduce the amount of biodegradable municipal waste (BMW) going to landfill. This is based on the requirements of the EU landfill directive and was implemented in different EU member states with different methods to determine the reduction of the biodegradables content in the waste (see section 3).

For the purpose of BMW diversion from landfill an MBT plant could simply compost all waste without any separation and landfill the residues. This might be a first stage of the development of a waste treatment system and would help to meet current legal requirements in terms of BMW diversion. It would be a straightforward solution which would not rely on markets for products from the process like RDF etc.

The more common approach is shown in figure 1 to combine the biological treatment with mechanical processing steps to separate products from the waste prior or/and after the biological treatment. The configuration can comprise a wide range of technologies and a wide range of products. This is reflected in the mass flow diagram which shows a fairly high range for the products that can be separated.

A common approach is the front-end separation of a RDF fraction which will be utilised in industrial processes like cement kilns, coal power plants, purpose built combustion facilities (e.g. to feed the energy to an industrial process) or in a mass burn incineration.

In case of a front end separation the material left after the separation stage is enriched with easily degradable components like kitchen waste and “dirty” paper, like tissues, which are not suitable for recycling. This material is then treated through an aerobic process (composting) where aerobic (oxygen breathing) bacteria and other micro-organisms digest organic wastes. In the process the bacteria grow and reproduce by using some of the energy and material in the organic matter. This process yields carbon dioxide and heat. The time taken for composting is usually determined by the rate at which the feed can be hydrolysed. Higher temperatures accelerate the hydrolysis stage, but the number of micro-organisms that can survive these higher temperatures is reduced.

The continuation of the composting process requires the addition of water. Water is needed to hydrolyse the feeds and progress the other biochemical reactions. The stabilised waste can then be landfilled. An alternative discussed in some countries in Europe is a compost like product that can be produced through a post-refinement stage. At this stage other material, like RDF or aggregates can be separated as well if a market is available and the process is economically viable.

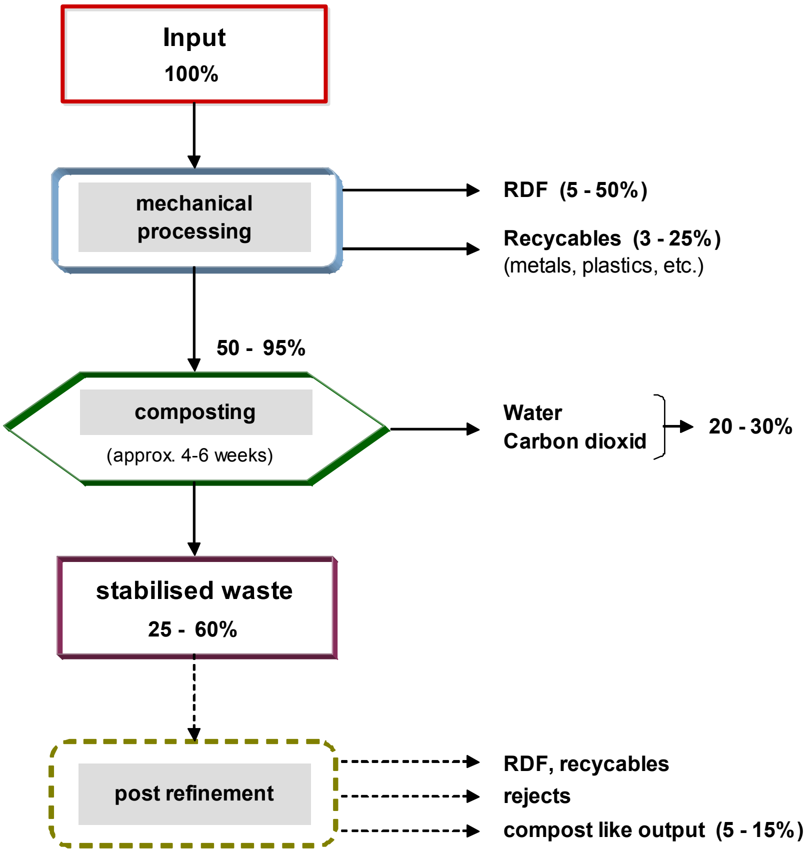

Figure 1: MBT for stabilisation

2.2 MBT with Anaerobic Digestion

Anaerobic Digestion is a biochemical process which takes place in a vessel in the absence of oxygen and results mainly in the formation of a carbon dioxide and methane gas mixture known as "biogas"

Anaerobic Digestion is very often referred to as a separate MBT approach. This might be justifiable for the aspect that renewable energy is produced. If looking at with respect to legal requirements for waste treatment AD is just one component of a MBT strategy. The most common approach where AD is involved is through the stabilisation approach. AD in such a context would then be used as the first stage of the biological treatment which focuses on the anaerobically easily degradable waste components. The "biogas" produced during digestion is used to provide internal electrical power generation and heating requirements. Surplus electrical power (and heat) can be sold as renewable energy.

The digestate is usually dewatered and treated aerobically (composted; often referred to as “maturation”). The purpose of the second stage is to further stabilise the waste, reduce the mass and reduce the odour of the material.

Figure 2 shows such an approach. The flow diagram looks very similar to the "stabilisation" approach. There is a significant impact in terms of process technology involved and the invest costs of such an approach are higher. On the other hand revenues from the biogas utilisation via CHP can be generated which might offset the higher investment costs.

An alternative to the approach of dewatering and further composting is the direct use of the digestate as a liquid fertiliser/soil conditioner. This is subject to meeting any legal requirements and conditions imposed. The key impact on the plant design will be in terms of achieving the sanitisation requirements imposed by the animal by-products legislation.

Figure 3 below shows the development of anaerobic digestion facilities in Europe for both biowaste (source separated kitchen and garden waste) and residual waste through MBT. It can be seen that anaerobic digestion of residual waste has rapidly increased over the last 5 – 7 years.

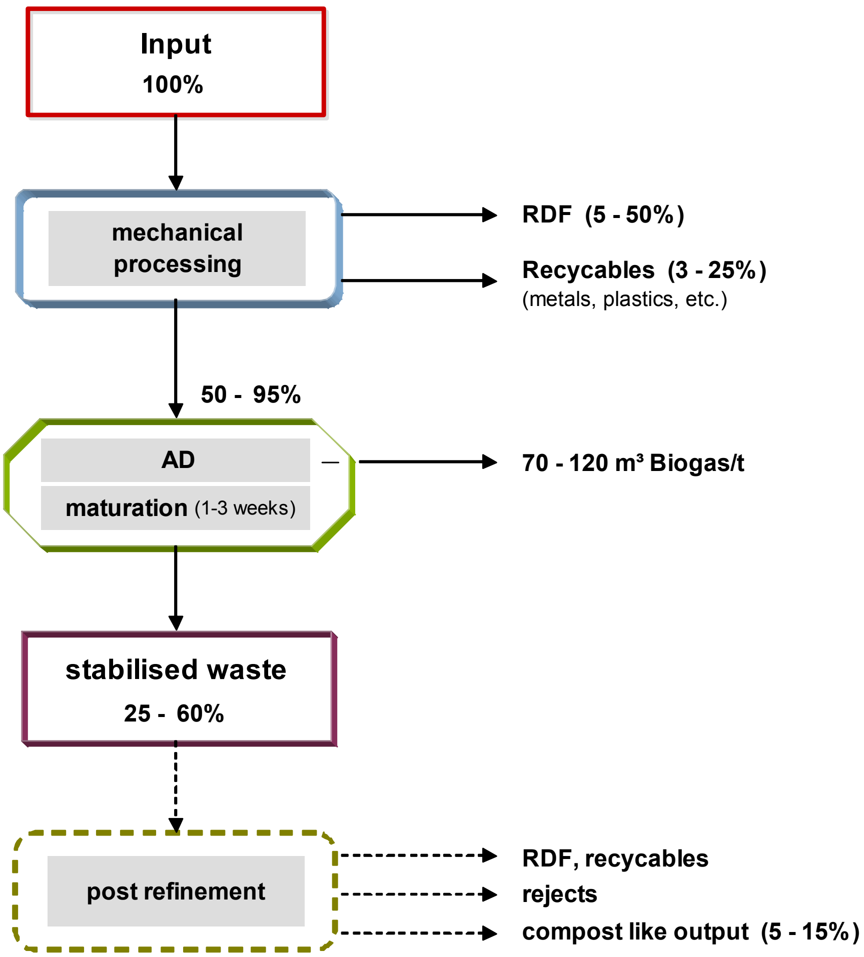

Figure 2: MBT with Anaerobic Digestion

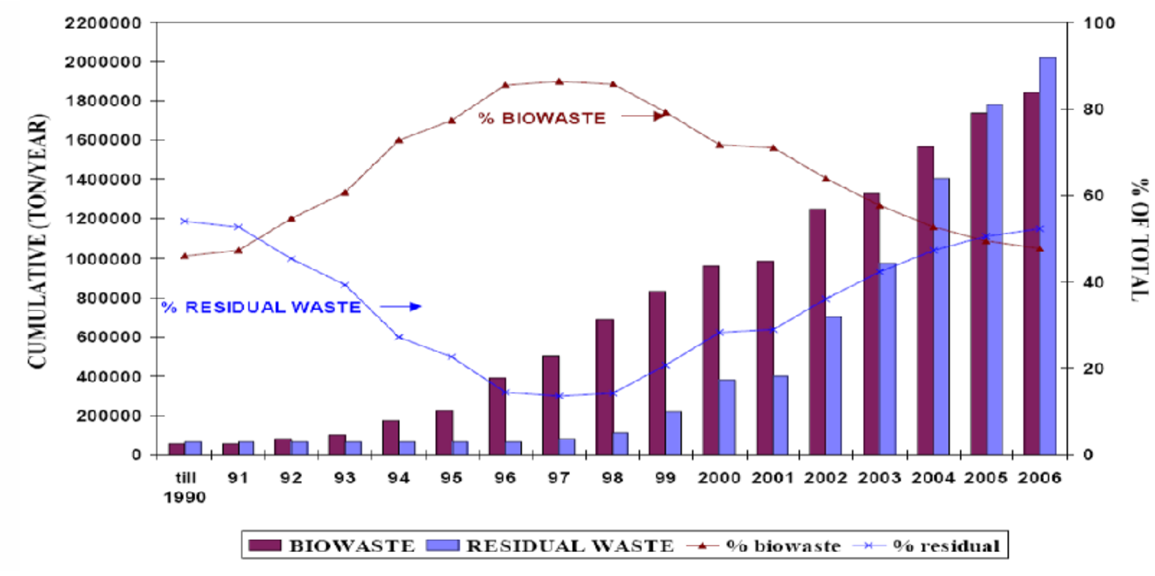

Figure 3: Development of MBT plants in Europe (deBare, 2007)

2.3 Biological Drying

“Biological Drying” is the other fundamentally different MBT approach. The scope of this approach is to make use of the energy content of the waste by means of the production of a (high quality) RDF which is the used for energy production.

The most well-known technology suppliers/developers of this approach are “Herhof” (Germany, now owned by the Greek civil construction company “Helector”) and “Ecodeco (Italy)”

The main purpose of the biological part of the process is to produce the heat which is used to drive of the moisture from the waste in order to enable easier and more efficient mechanical separation. Hence the mechanical separation is performed after the biological treatment.

The waste is shredded and placed in enclosed bio-drying boxes for a pre determined period. Air is forced through the waste creating optimum conditions for microbial respiration, and hence drying of the waste. The warm air is extracted from the boxes and is passed over a heat exchanger. Air passed through the boxes is re-circulated, which is significantly reducing the volume of exhaust air.

Often associated with the biological drying approach is the production of a high quality RDF which can be burnt in industrial plants like cement kilns for a lower price than in a combustion facility or mass burn incineration. Another benefit of the drying of the waste is the increase of the calorific value of the material. There are also a few examples of existing facilities where no biological system is used for the drying process but a physical drying is used instead using gas or oil to produce the heat for evaporating the moisture from the waste.

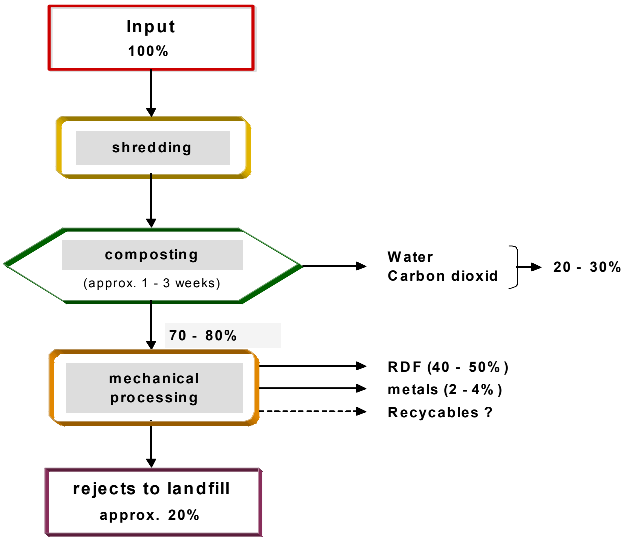

Figure 4: MBT – biological drying

3 Parameters to assess biodegradability

3.1 Background

The EU landfill directive requires a reduction of 65% in the amount of biodegradable waste which is landfilled (Art. 5). The main purpose of this requirement is a reduction in the adverse effect to the environment of the landfilling of untreated waste. The major problem with organic waste is that it degrades to the greenhouse gas methane in a landfill. Methane is a greenhouse gas that is 26 times more potent than Carbon Dioxide. Even with a state of the art landfill design incorporating methane capture, substantial amounts of methane will still escape to the atmosphere and contribute to global warming.

In Norway the government suggests the introduction of a threshold for biodegradable content in waste going to a landfill, defined by 10 % total organic carbon (TOC) or loss of ignition (LOI).

3.2 Parameters in different countries

While this general context is clear, the EU landfill directive does not give a clear guidance as to how to determine what is biodegradable. As methane is produced in landfills by a biological process, a suitable parameter to determine "organic waste" has to be established to measure it. In extensive research, predominantly in Germany, but also in Austria, Italy and other countries it has been demonstrated that several parameters may be used to determine the biodegradable content of waste. However, different biological tests measuring the aerobic (respiration) or anaerobic (gas formation) decomposition have been selected in individual countries and implemented in national regulations or guidelines:

Table 1: Parameters to assess MBT in different countries

Country	Parameter	Limits	Method/regulation
Germany	Static respiration index “AT4” Gas formation test “GB21”	< 5 mg O_2/g dm < 20 Nl/kg dm	Fixed in German landfill ordinance[1]
Austria	Static respiration index “AT4” Gas formation test “GB21” or “GS21”	< 7 mg/g O_2 dm < 20 Nl/kg dm	Fixed in Austrian landfill ordinance [2]
Italy	Dynamic respiration index (Adani method) DRI [3]	< 1,000 mg O_2/(kg VS x h)	Regional require-ments
England and Wales	Change of biodegradability in from beginning to end of a treatment process, biodegrad-ability parameters: - Biological methane potential in 100 days “BM100” - Dynamic respiration index “DR4”	No limits but deter-mination of the re-duction of the gas potential in a treat-ment plant	UK Envrionment Agency guidance[4]
Scotland	Change of organic content from beginning to end of a treatment process Assessment parameter pro-posed: - LOI (loss on ignition) Alternative approaches are pos-sible	Equivalent to Eng-land/Wales	Scottish guidance [5]
EU	Static respiration index “AT4” Dynamic respiration index (Adani method) DRI	< 10 mg O_2/g dm < 1,000 mg O_2/(kg VS x h)	2nd draft EU biowaste directive 2001, with-drawn [6]

1 German Ministry of Environment, 2001: Ordinance on Environmentally Compatible Storage of Waste from Human Settlements and on Biological Waste-Treatment Facilities; 20 February 2001; http://www.bmu.de/files/pdfs/allgemein/application/pdf/ablagerungsverordnung.pdf

2 Verordnung des Bundesministers für Umwelt über die Ablagerung von Abfällen (Deponieverordnung); modified 23.01.2004 StF: BGBl. Nr. 49/2004; http://ris1.bka.gv.at/authentic/index.aspx?page=doc&docnr=1

3 Riffutti e combustibili rcavati da rifiuti, Determinazione della stabiliata biologica mediante l´indeice di Respirazione Dinamico (IRD); UNI/TS 11184, ottobre 2006; www.uni.com

4 Environment Agency (2005): Guidance on monitoring MBT and other pre-treatment processes for the landfill allowances schemes (England and Wales); http://www.environment-agency.gov.uk/commondata/acrobat/the_final_outputs_1096040.pdf

5 Landfill Allowance Scheme (Scotland) Regulations 2005: SEPA Guidance on Operational Procedures; http://www.scotland.gov.uk/Publications/2005/06/08111144/11463

Whilst in other European countries parameters to assess the organic content in waste have not yet been implemented in the national regulations, the parameters and limits proposed in the 2nd draft EU biowaste directive 2001 are often used on a regional level.

The limits applied in Germany and Austria are somewhat stricter than in the 2nd draft of the EU biowaste directive. This is because the limits have been derived from an existing technical guideline ("TASI"; TA Siedlungsabfall), where limits for LOI (<5%) and TOC (<3%) were specified. In a court case it has been successfully demonstrated that the 3% TOC could be fully degradable organic material like sugar. From one tonne of waste with a 3% sugar content about 55 m³ of landfill gas could be produced in a landfill. This sets the benchmark for stabilised waste. It can then be demonstrated from repeated landfill simulation tests with biologically stabilised waste that waste with a respiration rate AT4 of 5 mg O_2/g dm shows a gas potential of usually less than 55 m³ landfill gas. Furthermore the gas potential of waste with an AT4 <5 mg O_2/g dm is reduced by over 90% compared to fresh, untreated waste. If assuming that the 65% reduction requirement in the EU landfill directive refers to a reduction of landfill gas production, then the limits set in Germany and Austria exceed the EU landfill directive requirements. A 65% reduction of the landfill gas production corresponds more closely with the limits set in the 2nd draft EU biowaste directive.

3.3 Which is the best parameter?

Much research has been done on the several parameters which are capable of measuring biodegradability, including various biological physical and chemical tests.. For many situations, correlations between the parameters has demonstrated that several parameters are, at least in principal, suitable for the determination of biodegradability.

In the regulations in place currently, biological parameters have been chosen because it is felt that they are more direct and comprehensible. In various round robin tests, the reliability and accuracy of the various parameters have been examined.

From these tests it can be concluded that the tests in place in Germany and Austria had been designed and approved suitable for biologically treated and stabilised waste. (AT4 below 20 -30 mg O_2/g dm)

With fresh waste, the AT4 test sometimes shows an unexpectedly low result and hence results from fresh waste need to be carefully assessed and revised if necessary. The same applies to the Italian DRI.

6 EUROPEAN COMMISSION; Working document; Biological Treatment of Biowaste, 2nd draft; http://www.compost.it/www/pubblicazioni_on_line/biod.pdf

Because of a different approach taken to assess MBT in England and Wales, the parameters proposed are more suitable for fresh waste. The disadvantage of these tests are that they are more complex (DR4) or take very long time (BM100, 100 days). The latter can cause problems especially during commissioning of new plants as it delays the determination of whether a plant is performing successfully or not.

One criticism of biological tests sometimes expressed is that there may be toxic substances in the waste which could inhibit biological activity during the test and hence show a lower biodegradability than in reality. Whilst this might be relevant for untreated waste it is less relevant for waste that comes from a biological treatment plant because if there was a toxic component in the raw waste it would have had an impact in the biological process and hence would have been detected earlier. Nevertheless, an additional non-biological test could be introduced in the Norwegian landfill regulation to mitigate this risk. At the moment there are experiments underway to develop such quick tests, the latest stage in the development of the various approaches should be assessed before selecting an appropriate parameter.

4 MBT Capacity in Europe

MBT is well established in many countries in Europe with major capacity in Italy (about 11 Mio t), Germany (5 Mio to); Spain (3 – 4 Mio t) and Austria (1 Mio t). Many other countries are introducing MBT and substantial plants are under development or proposed, for example, in the UK and France as well as in Eastern European countries .

Whilst in Germany, Austria and Italy the purpose of the biological process is to stabilise the waste prior to landfill, in other countries the production of low grade compost is a part of the MBT concept. Because of the higher content of pollutants compared to compost produced from source separated organic (kitchen and garden waste), the use of such compost can be very controversial. The major country to promote the use of mixed waste compost is France, but it is being discussed and used in several other countries.

5 Key Advantages of MBT

MBT is often perceived as a “greener” solution for the treatment of waste when compared with mass burn incineration. As a consequence, it is easier to obtain planning permission than it is for incineration.

MBT is based on existing and well known technology (mechanical treatment stages, composting)

MBT is a versatile and flexible concept which can be adapted to a wide range of conditions.

MBT can be economically viable for low waste quantities and be part of a wider waste infrastructure where, for example, several smaller plants which prepare the waste are combined with a bigger unit for producing fuel or recycled materials. This saves transport costs and adheres to the proximity principle.

Smaller scale plants built for a local community are often more acceptable to the public than bigger plants for a wider collection area. Hence planning consent can often be more easily achieved for such plants

MBT can be developed quicker than alternative treatment technologies and may be the quickest option for local authorities to achieve and therefore might even be the only realistic option to meet the UK´s (local authorities) LATS targets.

MBT is a fairly flexible system approach which can be adjusted to local conditions and treatment targets, it can be developed gradually through a /modular system and also cope with a wide range of waste quantities and waste types.

MBT can be developed to optimise the energy yield from waste, including the production of renewable energy via AD and heat and power via RDF combustion. With MBT a more uniform and homogenous fuel (RDF) can be produced which can be used more flexible and hence increase energy efficiency. As the energy production is decoupled from the waste treatment process the energy might be produced where it is needed and hence the overall efficiency is higher compared with a mass burn incineration.

MBT reduces the volume of residual waste due to the breakdown of the waste. This minimises the amount of landfill and therefore the landfill space taken for any residual waste, which maximises landfill resource.

Hazardous waste contaminants, such as batteries, solvents, paints, fluorescent light bulbs etc, can be separated through an MBT plant and it is a requirement that hazardous waste is not disposed of through municipal landfill sites and it is essential that it does not go through into the organic waste stream.

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