

# Research and Development Results of the Mechanical Biological Treatment Process NEW EARTH in the UK

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## Forschungs- und Entwicklungsergebnisse des MBA Prozesses NEW EARTH in Grossbritannien

### Abstract

Driven by the Landfill Directive from the EC as well as other factors, like the outbreak of foot and mouth disease in recent UK history and the strong position against incineration from the public, Compost Systems participated in an R&D program to design, build and operate a treatment facility in Wimborne (Southern England) to demonstrate alternative solutions to Landfilling. As it is still unclear today, if certain waste streams of household waste will not be returning to life cycle as growing medias or landfill cover (a practise that is very common in Africa, Asia and other parts of the world), the full sanitisation of the final product according to the ABPR (Animal By Product Regulations) ECN1774/2002 was an additional target for the R&D program.

### Keywords

Treatment of household waste, mechanical waste treatment, biological degradation, respiration rate, TOC - total organic carbon, VOC - volatile organic carbon, dry matter balance, fresh matter balance, emission control, Wimborne, Canford, new earth, bio aerosols, aeration, sanitisation, seed germination, temperature development, service maintenance, health & safety on waste facilities

## 1 Client & Site Location

On the site of WH White plc in Wimborne, England, the facility was erected by WH White, for Canford Environmental Ltd, to run research trials for mechanical-biological treatment of household waste.

The facility, consisting of a 6,000m<sup>2</sup> building with a reception, biological treatment as well as a post treatment area. Compost Systems were responsible for designing the biological treatment process, with influence to the pre treatment as well as post treatment process design.



Fig. 1 Treatment facility in Wimborne

## 2 Setup and organisation

### 2.1 Receipt of the material and pre treatment

The product was delivered in standard waste trucks and tipped into the reception hall. With a high torque waste shredder the material was conditioned and screened by an 80mm screen. The undersize material was the target fraction to be treated by the biological process. On further trials the oversize fraction was reshredded to the point until no oversize was produced and all material had passed through the 80mm screen.

### 2.2 Material splitting

As the content of the organic fraction in the UK is still very high, the ratio of undersize fraction going into the biological treatment process was approx 2/3 of the total waste stream.

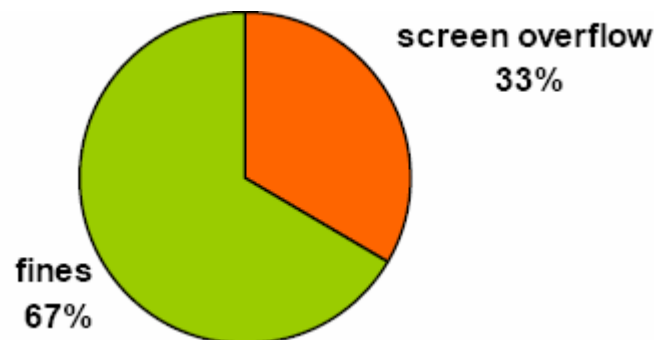


Fig. 2 Screening result

The oversize fraction was naturally holding high values of recyclable material, but as the recycling systems in the UK were not in place to handle side streams, the oversize fraction went straight to landfill under these trial conditions.

### 2.3 Biological treatment system

After evaluation of various methods, the system used for the process was a typical housed windrow system. The windrows were approx 4m wide and 2m high with a cross section of approx 6m<sup>2</sup>. The turning machine was a market available Compost Turning machine “UNI 4001” consisting of a self driving combustion engine vehicle with a front loading rotor and a transport belt. The turning machine leaves no space between the piles and therefore optimizes the building space.



**Fig. 3** Scheme of the biological treatment facility

The windrows were aerated by a negative aeration system under the piles. The extracted air was cleaned by a biofilter plant. The process temperature was measured by a remote temperature probe and sent to the process control computer to adjust aeration frequency by process measures. The process was fully automatic, apart from requiring a driver for the turning machine.

## 2.4 Sanitary aspects

Driven by the ABPR 1774/2002 and the recent outbreak of disease in the UK, the aspects and measures of sanitisation control was of great value. It was a clear decision that even if the material would go to landfill after the process, the design and the measures should meet the standard requirements of the State Veterinary Service of a composting facility. It was a further aspect that all automatic equipment in enclosed reactor buildings would have large problems meeting cleaning procedures. Also sanitary requirements did not make it easy to work in these biological treatment buildings. This was the main reason why equipment like stationary conveyors inside the halls, or a stationary turning machine etc were not used due to the service and maintenance regimes for cleaning as well as employees working environment inside these composting reactor buildings.



**Fig. 4** Example: Maintenance of the equipment

*Stationary equipment is hard to clean, the environment inside these buildings is very hot and high moisture saturation! Working conditions are equal to working in a steam sauna.*

So the alternative was a mobile working unit which could be transported outside the building after the turning process.





**Fig. 5** Turning machine

However, as the driver inside the self contained machine remained inside the machine as operator, it was a critical aspect to detect the suitability of the working environment for a human worker. As the population of micro organisms gets very high in composting facilities, it was a part of the research trials to measure the impact of germs (airborne disease) on the equipment operator and how well today's methods of protection would protect the driver against unhealthy impacts.

## **2.5 Quality measures**

### **2.5.1 Environmental impact**

Monitoring emissions to air, such as gas or noise emissions, as well as liquid leachate during the treatment time was one of the most important measures.

### **2.5.2 Cost efficiency**

Obviously the final measure is always a question of economical suitability to the comparable market prices. As the main competitor for MBT plants in the UK remains landfilling, the short term pressure is to compete with today's landfill rates, where as long term, the rates for landfilling will dramatically increase by the requirements of landfill diversion and emission control.

### 2.5.3 Final product quality and digestion loss

As regulated by EC, the new European Standards required a dramatic reduction of emissions produced by future landfills. So not only the pure digestion loss of the total mass was considered but, much more importantly, the level of activeness / stability in the material going to landfill was used as a Q.S. measure to determine the digestion quality of the process. During the trial, the UK levels were not set so the comparison level from Austrian and German regulations were used, which requires the activity of the final product to remain below AT4 5mgO<sub>2</sub>/g in Germany and AT4 7mgO<sub>2</sub>/g in Austria.

### 2.5.4 Health and safety, upscaling, real life operation

As it is known in the industry, that many great ideas that work well under research conditions, it can be a challenge to force these technologies into reality. Not only health and safety measures, but also servicing intervals, accessibility, likeliness of failure, impact on humans and equipment as well as possibility of upscaling and possible dangers and effects.

## 3 Results

### 3.1 Level of degradation

In the trials, 2 variations of samples were used to compare the results. In Sample Nr 18 the received material was shredded until small enough to go into the treatment reactors, while trial 20 was screened after shredding at 80mm and the screen oversize was removed from the process before treatment.

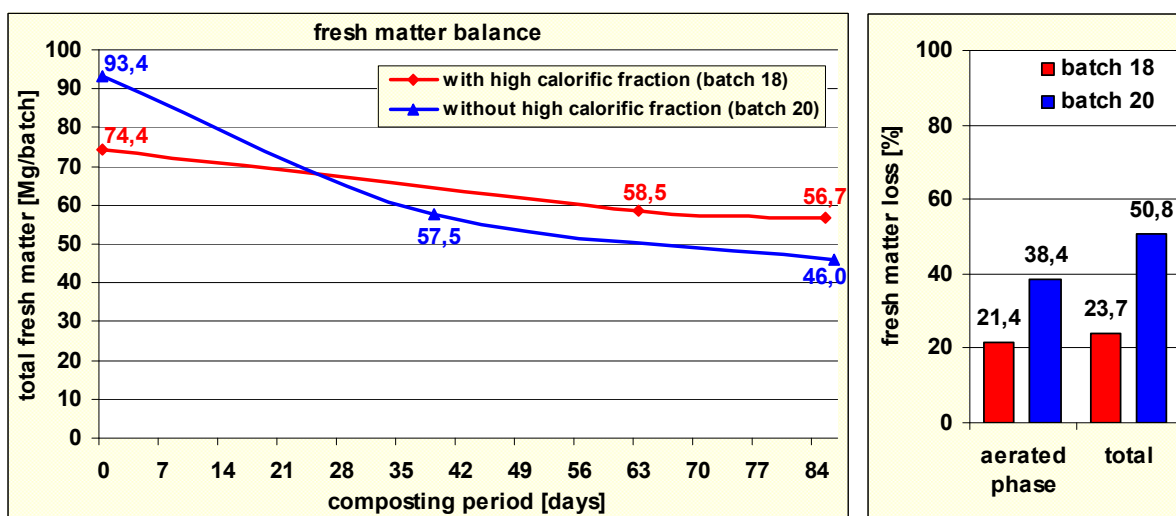


Fig. 6 Fresh matter balance

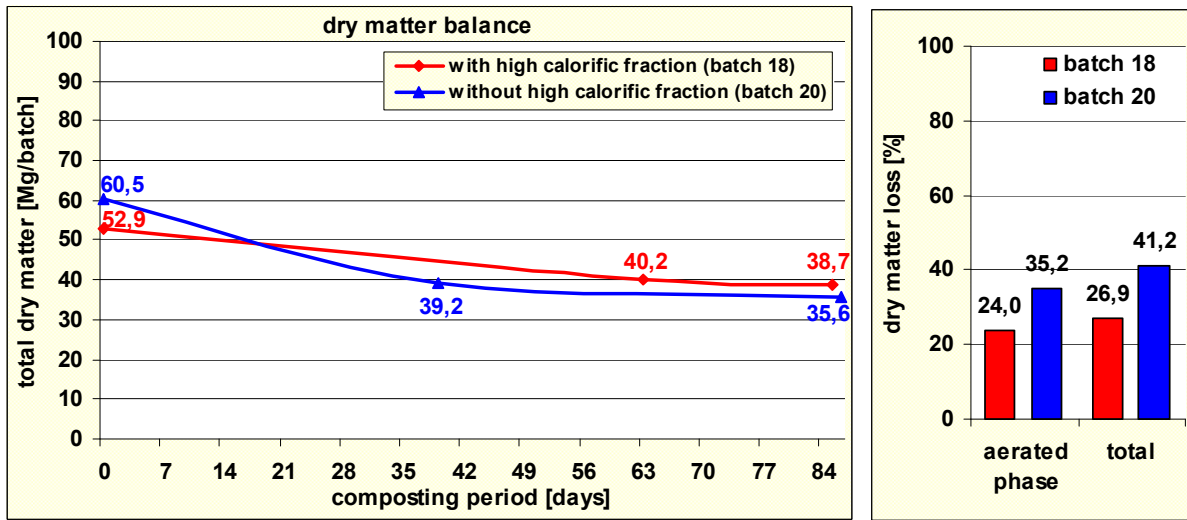


Fig. 7 Dry matter balance

As the level of moisture loss can only be considered as a minor factor in MBT treatment, it is important to look at the total degradation of dry mass by the process. Waste reduction by dehydration is not considered a suitable method to function as an MBT process in most European countries. As the test results show, most of the activity in dM reduction was finished after approximately 4 to 5 weeks.

### 3.2 Respiration Rate

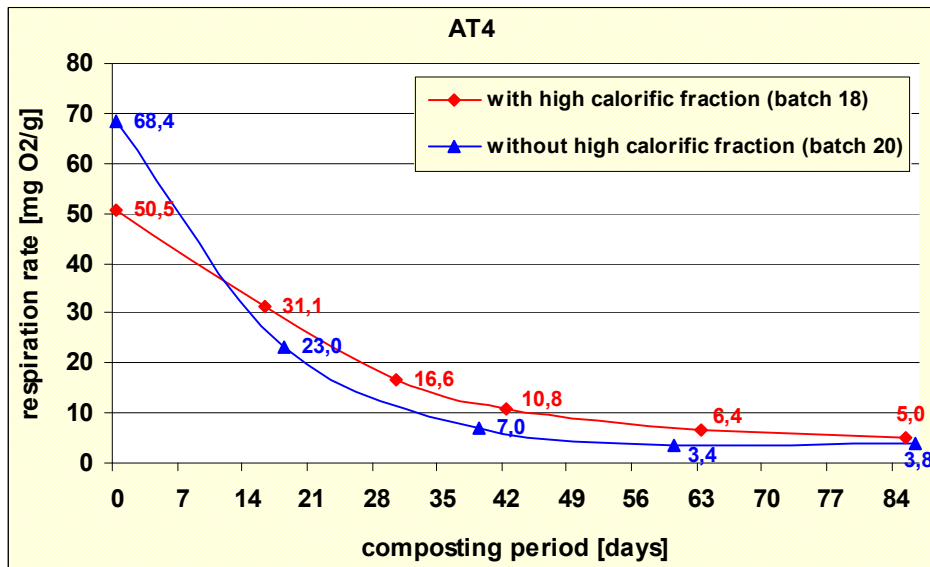


Fig. 8 Respiration rate

Suitability of biologically treated material going to landfill is measured in most EC countries by the remaining biological activity i.e. oxygen demand. In Austria and Germany the regulations require material over an oxygen demand of 20mg/O<sub>2</sub>/gAT<sub>4</sub> to remain in closed systems, where material under 20mg/O<sub>2</sub>/gAT<sub>4</sub> can be cured outside until the final landfill criterias are reached. In the representative trial batch 20, the target 20mg was reached within approx 3 weeks. The indoor process however shall remain for 4

weeks for reasons beyond respiration rate. Surprisingly after a composting period of approx 6 weeks, the respiration rate had already reached the level that would allow the material to go to landfill in Austria. The level for Germany took approximately 2 weeks longer. Other tests like the GFR 21 (Gas Formation Rate in 21 days) were showing equal results.

### 3.3 TOC Eluate

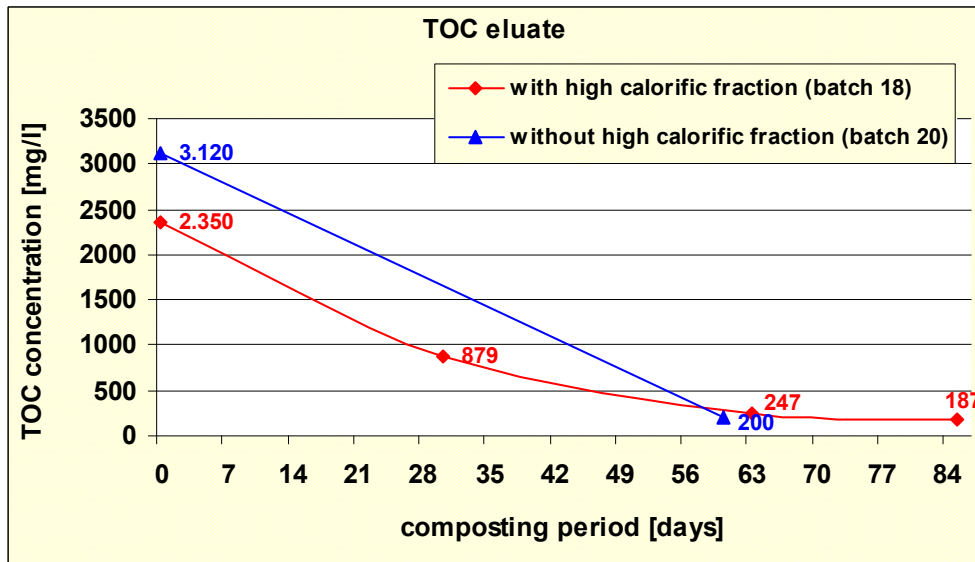


Fig. 9 TOC eluate

The required level of 250mg/l of Eluat for landfilling in Germany and Austria could be reached between 6 and 8 weeks treatment time.

### 3.4 Gas Emissions

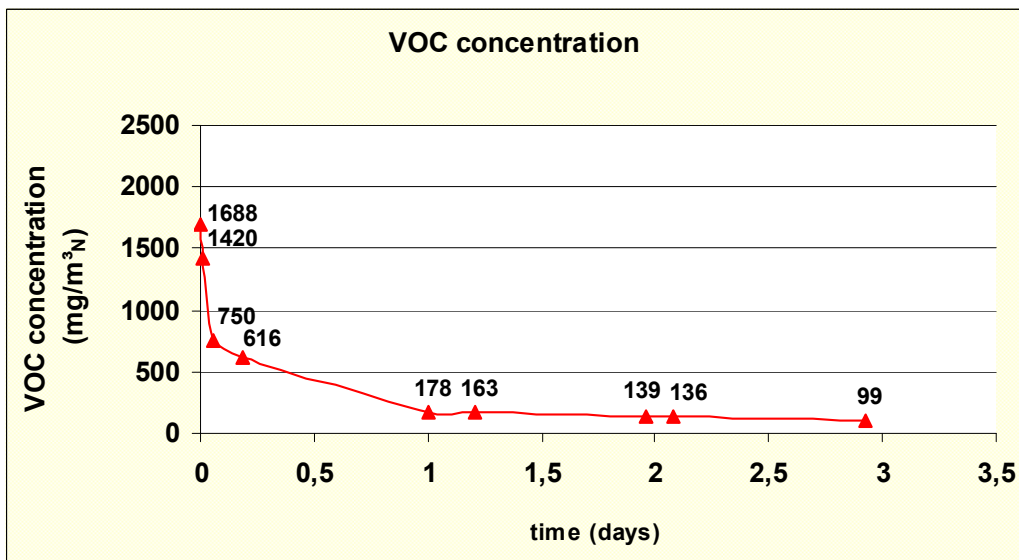
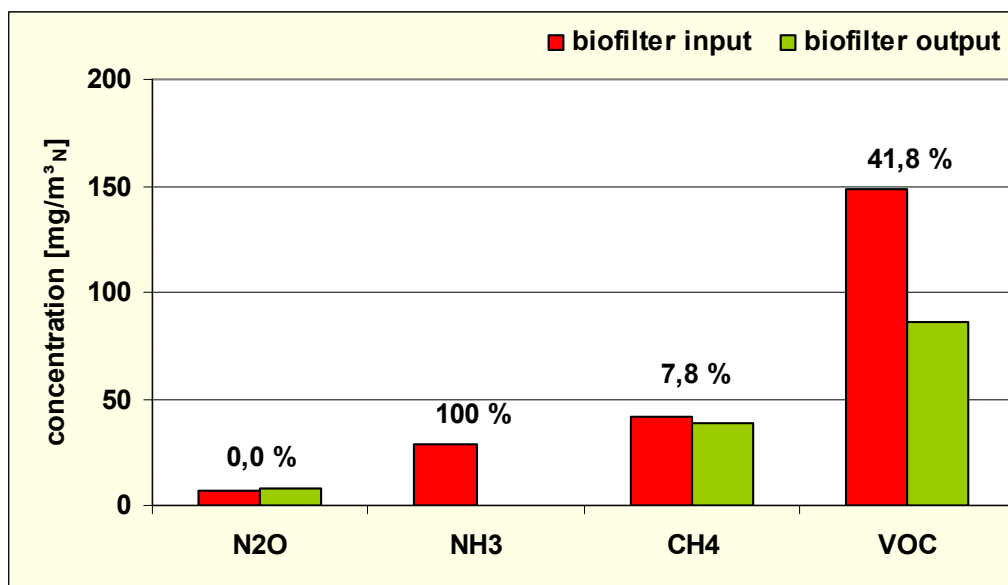


Fig. 10 VOC concentration



After a relatively short time, the VOC emissions were stabilised by the process and reduced to a level of less than  $100\text{mg}/\text{m}^3$  within 3 days. This reflects a reduction of 94.2% in only 3 days.



**Fig. 11** Gas concentrations of the input and output

The air cleaning of the exhaust air was performed by a biofilter plant. Next to a significant odour reduction, which remains the main purpose of a biofilter, the NH<sub>3</sub> emissions could be completely reduced, while the VOC could only be reduced by 41.8%. Naturally, the CH<sub>4</sub> emissions could not be significantly reduced, however the low exhaust levels of the process air of less than  $50\text{mg}/\text{m}^3$  required no additional cleaning setups.

### 3.5 Health and safety

As health and safety on waste treatment facilities becomes an ever more important issue, the important measuring locations were detected during the trials. As gas measures inside the buildings, machines and reactors have never shown any results for air being unsuitable in levels of O<sub>2</sub>, CO<sub>2</sub>, or CH<sub>4</sub>, the more critical level for health and safety was the impact of bio aerosols. As there are no service and maintenance points inside the reactor buildings besides turning with the mobile turning machine, the measure of impact to humans could be seen as worst condition during turning.

**Sampling on 27/5/04 Bacteria**

Details of Siting	cfu/m <sup>3</sup>
In turner prior to turning	833 < 100
Attached to turner outside	250 83
In hall prior to turning	1,000 1,500
Attached to outside of turner during turning	+110,667 +132,667
In turner during turning	250 416
In large pipe during/after turning	1,750 1,750
Biofilter during/after turning	1,000 1,166

+Sample 4 overloaded, more likely over 10<sup>6</sup>

**Sampling on 27/5/04 Fungi**

Details of Siting	cfu/m <sup>3</sup>
In turner prior to turning	< 100
Attached to turner outside	< 100
In hall prior to turning	< 100
Attached to outside of turner during turning	+8,583 +7,583
In turner during turning	< 100
In large pipe during/after turning	< 100
Biofilter during/after turning	< 100

+Sample four overloaded, more likely +10<sup>7</sup> (of *A. fumigatus* only)

**Fig. 12** Bio aerosols concentrations

As expected, the worst situation was found in the buildings during the turning operation. While the building air inside the biological reactors was showing only approx 1000cfu/m<sup>3</sup> air, after turning this value went up to 110.000 / 130.000cfu. However, during turning the air inside the cabin actually improved in quality and reduced from 833cfu to approx 250 to 400cfu. This reduction explains itself by the internal carbon filter inside the driver's cabin which gives additional air improvement to the existing cabin air. Besides ensuring that the driver did not open the cabin during operation and ensuring no access to the facility for unprotected humans, the operator for the machine was not exposed to these unsuitable building climate conditions during operation. However, these results had major impact on future design requirements. As conditions were not found particularly healthy at any time of the process, service and maintenance of equipment inside the reactors had to be reduced to minimal level. This resulted in the requirement to ban all moving parts like conveyors, air handling fans etc. and most electrical components, except the lights within the Reactor buildings.

### 3.6 Sanitisation of final Material

As sanitisation is a major issue in the UK, one of the self imposed targets in the trials of the New Earth process was the sanitisation of the material according to the ABPR 1774/2002 ECN. As the final product from MBT plants is normally sent to landfill, there is still the open question to divert certain screened fractions back to the environment, for instant landfill cover, or re-cultivation soil. In countries outside of the EC it is still common practise to use household waste “compost” as a fertilizer on agricultural land. The first indicator of full sanitisation is the distribution of temperature inside the material. For this purpose several temperature sensors were placed inside the piles and monitored during the full process time.

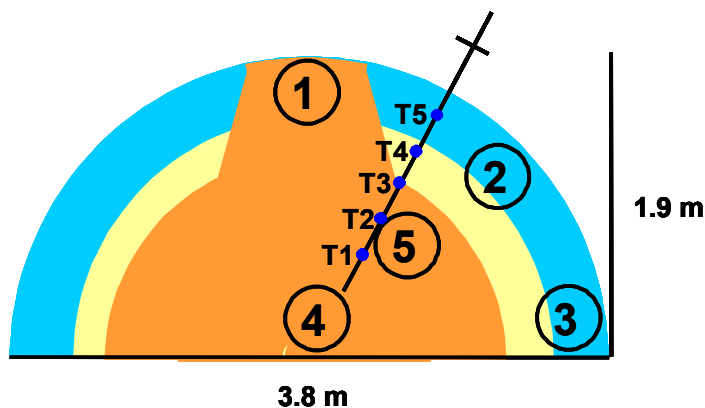


Fig. 13 Points of measurement

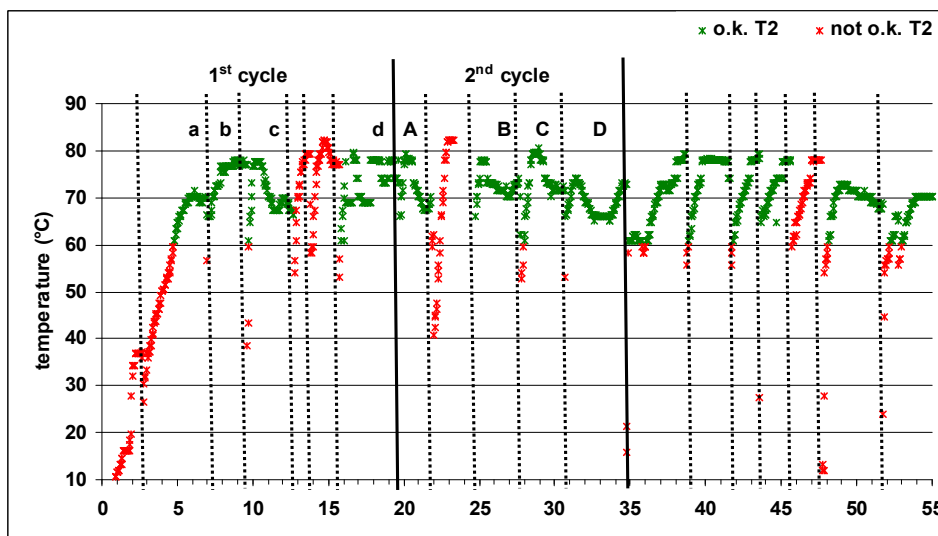
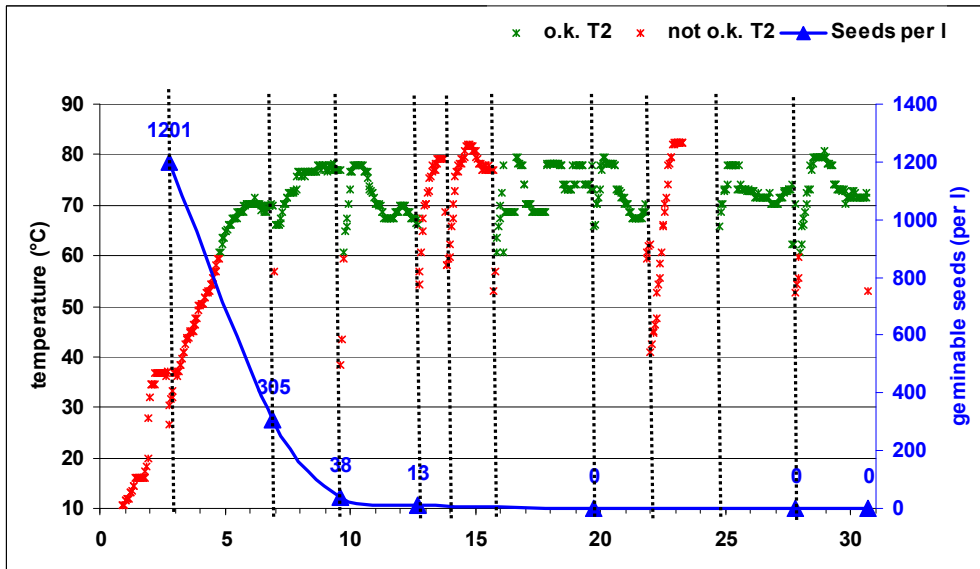


Fig. 14 Temperature development

The temperatures inside the material showed that the required temperature levels for sanitisation were reached. However, the outside skin of the piles would always remain at ambient temperature and would not get the inside heat. By turning the material frequently, all material should end up inside the hot zones at some point and get full sanitisation. This effect was tested by the implantation of tomato seeds.



**Fig. 15** Temperature development and germinable seeds

By the implementation of approx 1200 germinating seeds per litre of fresh material, the remaining ability of germination showed when all material reached full level of sanitisation. The above graph shows that after 2 weeks and 4 turning cycles, all material had reached full sanitisation and no further germinating seed could be found in the sample. Additional tests with the implantation of Tobacco Mosaic Virus showed similar results, where full sanitisation was proven before material left the reactor building.

### 3.7 Cost efficiency and real life implementation

As the detailed cost effectiveness is a confidential issue for the client, details cannot be revealed. However the recent expansion of the facility in Wimborne South England as well as other locations in the UK, with capacity levels of 50,000t to



**Fig. 16** Wimborne treatment facility

100,000t/year show that the economics are suitable to compete within the market. As the technology is based on individual biological treatment reactors, no upscaling problems were experienced during the expansion of the site.

## 4 Summary

Within the test trials at the Canford NEW EARTH MBT plant, the complete process of biological treatment was tested on its performance and suitability for today's requirements on EC regulations as well as economic requirements. The material tested was non separated household waste (blackbag), where the oversize light fraction was removed after shredding and before biological treatment. During the treatment time of approximately 4 weeks, the level of degradation reached approximately 35%DM loss (approximately 40% after curing). The level of stabilisation of the material to go outside of the biological reactors (20mgO<sub>2</sub>/g AT<sub>4</sub>) was reached after 3 weeks. The criteria for landfilling, measured on the interpretation of Austria or Germany, were all reached within 6 to 8 weeks of total treatment time. This included a respiration rate of < 5mgO<sub>2</sub>/g/AT<sub>4</sub> as well as TOC in the Eluat <250mg/Litre. The health and safety analysis study resulted in the requirement to remove all service items from the treatment buildings to prevent any bio aerosol impact to humans. The workers could only access the reactor building when protected inside an air conditioned cabin with a special overpressure filter system. The impact on service and maintenance personnel inside the reactor buildings was found to be unacceptable in terms of bio Aerosols, temperature and air saturation. From a sanitary point of view, test results had shown that material leaving the enclosed plant after a treatment time of 4 weeks, was fully sanitised according to requirements of the EC 1774/2002 ABPR (Animal By Product Regulations). The R&D project had shown full suitability for the process to meet the required EC Standards of the Landfill Directive. As the process takes place in single enclosed reactors, upscaling to larger facilities only opens logistical questions but does not change the process itself. The process is suitable to be expanded to real life treatment plants, as the expansion of the treatment plant in Wimborne and several other locations in the UK has proven, even under the price-restricted financial situations in the UK, where MBT plants still need to compete against the traditional practise of Landfilling.



## 5 Literature

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Dr. Wolfgang Mueller (IGW)  
Dr. Jon Pickering (ORA)  
T. Gladding (Roffco Environmental Monitoring Services)  
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