Results of continuous measurements of exhaust gas from intensive processing

Matthias Kuehle-Weidemeier

Wasteconsult international, Langenhagen, Germany

Abstract

Regenerative thermal oxidation (RTO) is a very effective way to treat especially gaseous organic emissions (VOC) from mechanical-biological waste treatment (MBT) plants. To reduce the exhaust gas treatment costs, it is advantageous, to reduce the exhaust gas volume and enrich the VOC content to a certain level. Composting tunnels with small head space and good controllability for the biological treatment prevent unnecessary air volumes and allow to run the process with low oxygen contents in the exhaust gas. The paper presents the results of 2 tests run at exhaust gas O_2 levels about 13% where VOC, methane (CH4), ammonia (NH_3) and laughing gas (N_2O) were continuously measured in order to find a database to dimension the RTO.

Keywords

MBT, exhaust gas, RTO, VOC, greenhouse gas, gaseous emissions

1 Introduction

Germany and Austria have strict limitations / boundary values for the gaseous emissions from mechanical-biological waste treatment plants (MBT) which are shown in table 1. These values can’t be kept without air treatment, which usually needs a thermal unit to eliminate the volatile organic carbon sufficiently. For an adequate design and capacity of the air treatment system, the knowledge of the emission developing during the processing time is essential. To reduce the effort for the thermal air treatment, the exhaust gas volume should be minimised. This leads automatically to a reduced content of O_2 and an enrichment of volatile organic carbon (VOC) in the exhaust gas. The VOC reduces the demand of external fuel for regenerative thermal oxidation (RTO) as exhaust gas treatment.

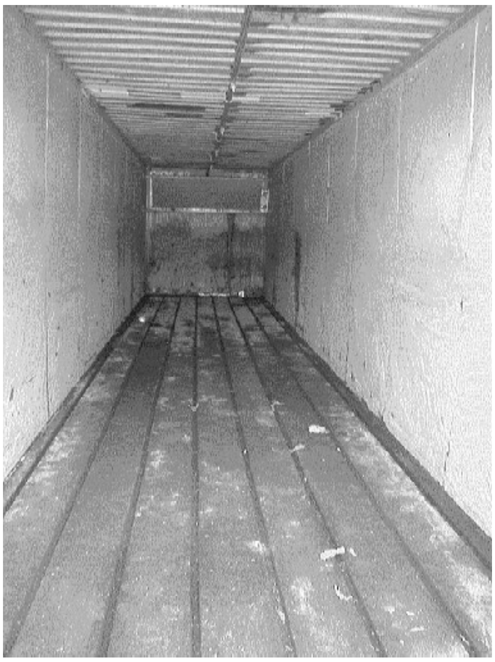
Most emissions are produced during the biological treatment. This paper describes the measured emissions of an optimised aerobic tunnel process. The tunnel allows a precise air balance in opposite to huge hall “composting” units which have lots of leakages and handle enormous air volumes. The tunnel was properly sealed to avoid an incorrect air balance caused by leakages. All tests were done by order of the waste management of Schaumburg County, Germany. The results of 2 tests (3rd and 4th test) are presented in this paper. The empty tunnel and a screenshot of the control system are shown in Figure 1.

Table 1 Boundary values for gaseous emissions from MBT (Stockinger et al. (2003)

Standard given for	period	Germany		Austria	
Dust	daily mean	10	mg/m^3	10	mg/m^3
	½ h-mean	30	mg/m^3	- / -	
Dioxin	no value	> 0,1	ng/m^3	> 0,1	ng/m^3
Total organic carbon	daily mean	20	mg/m^3	20	mg/m^3
	½ h-mean	40	mg/m^3	40	mg/m^3
	load [1]	55	g/Mg	100	g/Mg
Nitrous Oxide	load [1]	100	g/Mg	- / -	
Odour	all values	≤ 500	OU/m^3	≤ 500	OU/m^3
Nitrogen oxide – NO_x (calculated as N2O)	daily mean	- / -		100	mg/m^3
	½ h-mean	- / -		150	mg/m^3
Ammoniac		- / -		20	mg/m^3

1) Emission of the pollutant applied to the weight of the waste input to the treatment plant (weight specific emission / standard (monthly mean):
Load = Waste Input (into plant) * Exhaust Air Volume * Concentration)

Figure 2 is a schematic diagram of the air management system. The mixture of recirculation air and fresh air (together the supply air) is dependant on the desired amount of oxygen in the exhaust gas. To avoid an overheat of the tunnel, the recirculation air can be cooled. This was usually necessary, when the amount of oxygen in the exhaust gas was lower than 17%, when the air volume and therefore the heat transport capacity of the exhaust gas was to low.



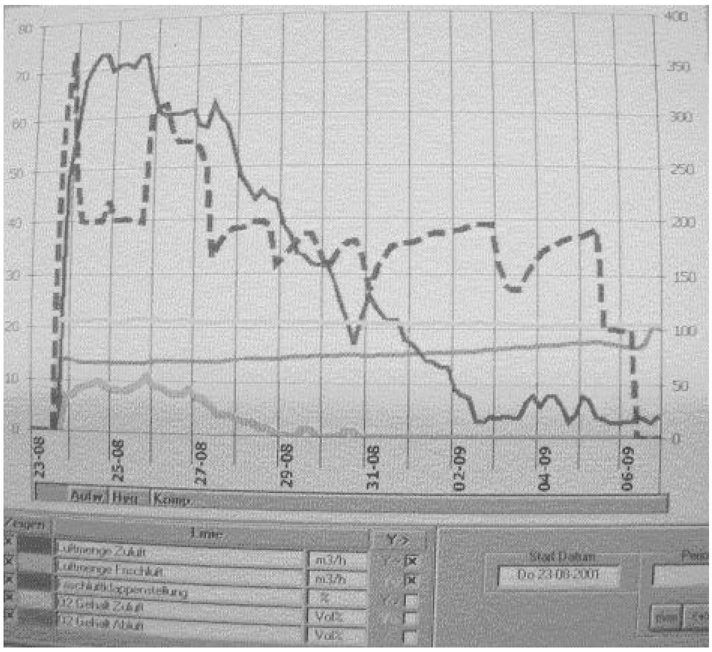


Figure 1 Tunnel for biological treatment and tunnel control screen

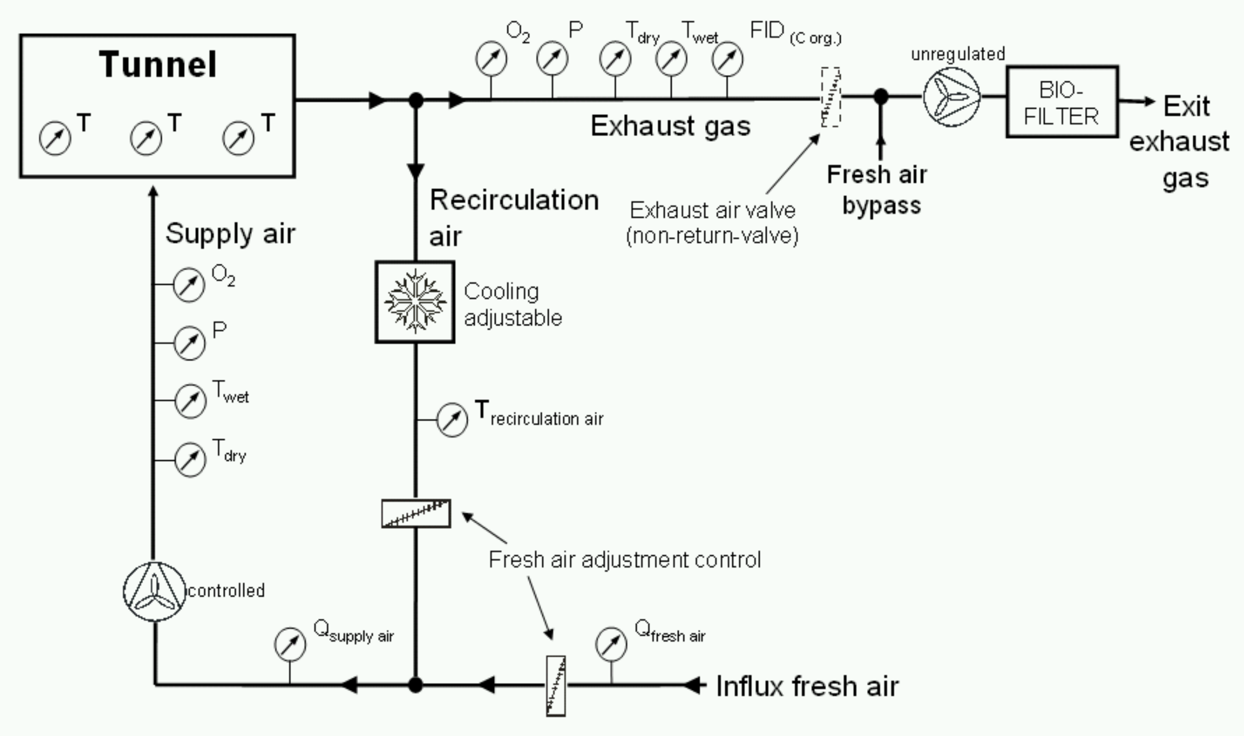


Figure 2 Air management system of the tunnel (supply air = recirculation air + fresh air)

2 Origin and preparation of the waste

The tunnel, which was built of a steel container, was designed for a waste volume of 40m³ which was filled with about 25 t of mechanically treated municipal waste < 80 mm. The MBT input was a representative mixture of household waste, commercial waste and bulky waste from Schaumburg County. More information about the material and the tests can be found in Kuehle-Weidemeier et al., 2003.

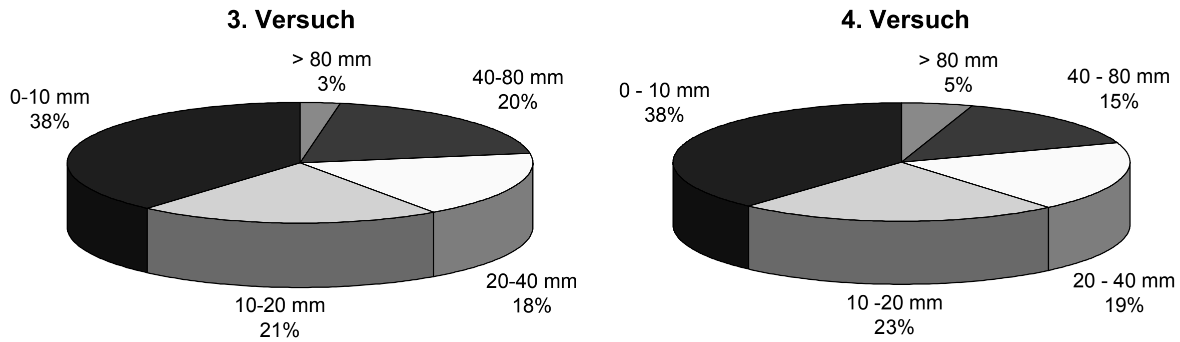


Figure 3 Particle size distribution of the tunnel input of 2 tests (“Versuch“)

3 Biological treatment

The biological treatment of the 3rd and 4th test was quite similar, because test 4 was done to confirm the excellent degradation results achieved in test 3. Table 2 summarises basic conditions of test 3 and 4. The German boundary values for the biological stabilisation were reached earlier in test 4 because the start AT_4 was much lower in this test (see table 3). The German boundary value for encapsulated was reached after 3 weeks or less. Figure 4 shows AT_4 and GB_{21} development during the biological treatment. Although the oxygen content in the exhaust gas was just 11 – 13%, outstanding results were achieved.

Table 2 Summary test 3 and 4

Treatment duration	3rd test	4th test
Tunnel composting, actively aerated	5 weeks	4 weeks
Extensive open composting, passively aerated	8 weeks	8 weeks
Total duration biological treatment	13 weeks	12 weeks
Adjustments tunnel composting		
O_2 exhaust gas	11 – 13 %, last week higher	10 - 13 %
Temperature	Mostly 55 - 65°C	Mostly 53 - 60 °C
Moving intervals	9 - 13 days	8 - 10 days
Extensive open composting (post processing), passively aerated		
Moving intervals	7 days	Mostly 7 days
Max. temperature in the moving cycles	45 - 75°C	46 - 59 °C

Table 3 Achievement of boundary values in test 3 and 4

Time lapse and achieving of German boundary values	3rd test	4th test
Start AT_4 [mg O_2/gDM]	79	46
AT_4 < 20 mg O_2/gDM (boundary value for encapsulated operation)	3 weeks	2 weeks
AT_4 < 5 mg O_2/gDM or GB_{21} < 20 NL/kgDM (alternatively usable boundary values for landfilling)	AT_4 11 weeks GB_{21} 3,5 weeks	AT_4 8 weeks GB_{21} 3 weeks
TOC_{Eluate} < 250 mg/L (boundary value for landfilling)	6 weeks	3 weeks

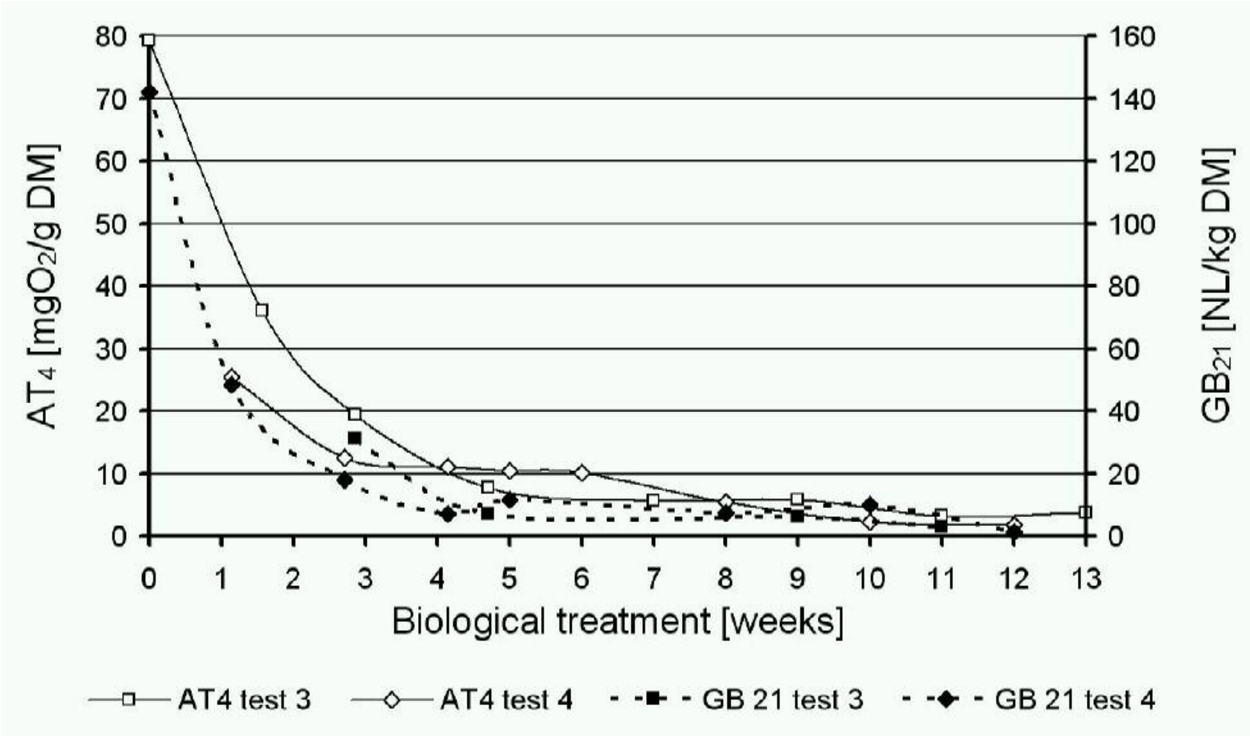


Figure 4 Development of AT_4 and GB_{21} during the biological treatment

4 Emissions

4.1 Measurements

Most important target of the continuous emission measurements were VOC which were already known to be the most critical parameter amongst the boundary values for emissions from MBT. To find out which share anaerobic processes have in the generation of VOC, Methane was measured continuously too. Furthermore ammonia (NH_3) and laughing gas (N_2O) were continuously measured.

The German ordinance for MBT emissions determines that the MBT-process has to be encapsulated. After the biologically treated material has reached an AT_4 < 20mg O_2 / g DM it can be permitted (decision of the local authority) to continue the biological treatment in an unencapsulated environment, which reduces the treatment cost. Hence the treatment duration in the tunnel were limited and supplemented by passively aerated open air treatment under a tent roof. This paper documents the measurements during the encapsulated tunnel treatment.

4.2 VOC during tunnel treatment

The VOC concentration in the exhaust gas is strongly influenced by the air regulation of the tunnel. Figure 5 shows as an example the VOC concentration of test 4. During the first 2.5 weeks the VOC concentration is mostly at least 1000 mg/m³ and temporarily much higher. The drop from the third to the fifth day was caused by a strong increase of the aeration. After 20 days no more fresh air was added (no exhaust air left the system) therefore the concentration was measured in the exhaust air path which lead to the recirculation air. The oxygen demand of the well degraded material was already quite low.

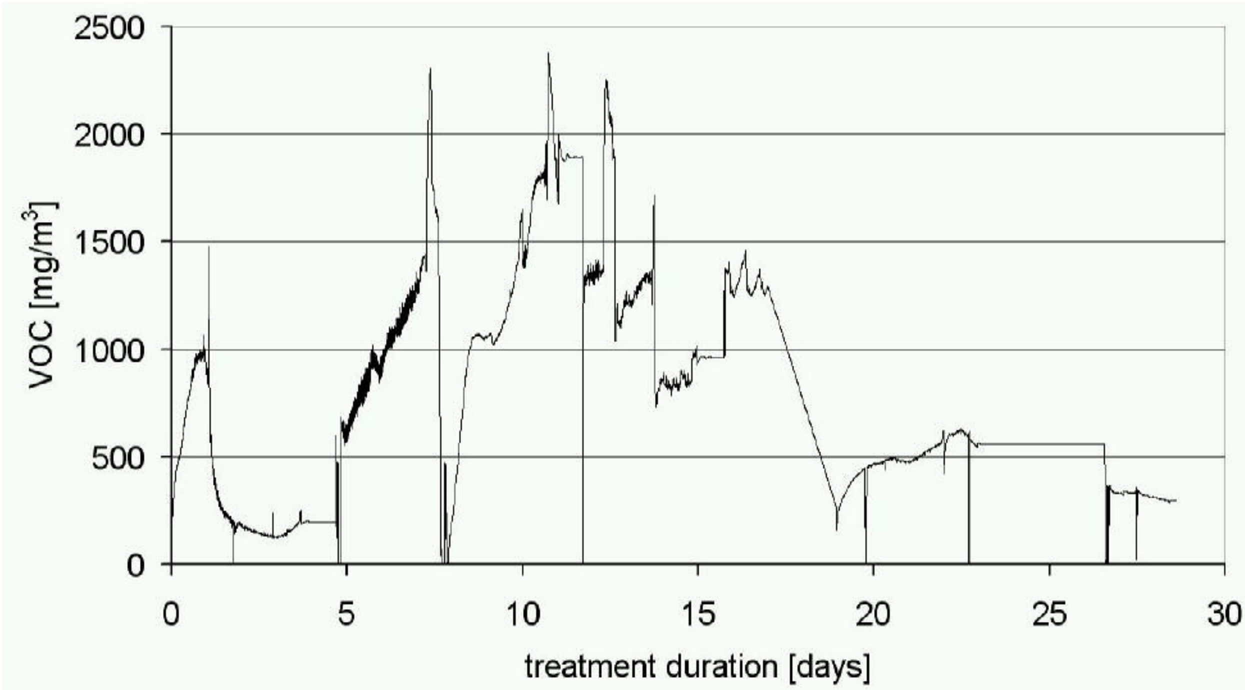


Figure 5 VOC concentration in the exhaust gas of test 4

The VOC concentration in test 3 was lower. The higher start AT_4 was associated with a higher oxygen demand. Hence the aeration and air exchange rate were significantly higher (see table four). The gas was thinned and the intensive aeration reduced the areas with bad air supply, where otherwise methane could be generated. The VOC concentration is important for the exhaust gas treatment. If the VOC concentration is at least 1500 mg/m³, an auto thermal operation of a RTO (regenerative thermal oxidation) is possible (Stockinger, 2003)

Figure 6 shows the curves of the total load emitted in test 3 and 4. Test 3 has nearly double start AT_4 compared to test 4 and the VOC emissions of test 3 are also nearly double. The emission behaviour during the tests can be explained as follows: Parallel to the biological degradation (see Figure 4) the first 2 weeks of the biological treatment cause the largest part of the VOC emissions. in the first days when the material heats up, VOC which are already in the waste material are stripped out. This is supported by fresh surfaces and broken cases caused by the prior mechanical treatment. Additional VOC is created by the biological degradation process. Later on methane emissions from slightly anaerobic zones become the most important factor for the VOC emissions. The $C(CH_4)$ / VOC ratio (Figure 7) underlines this. Tests with higher O_2 content in the exhaust gas produced less methane.

In the last part of the tunnel treatment the biological activity was already quite low and so was the oxygen demand. For longer periods (6-11 days) the tunnel was only run with recirculation air which means, that no VOC load was emitted out of the tunnel. These periods can be identified as the constant parts at the end of the VOC load curves. Table 4 summarises VOC data and contains loads related to MBT and to tunnel input.

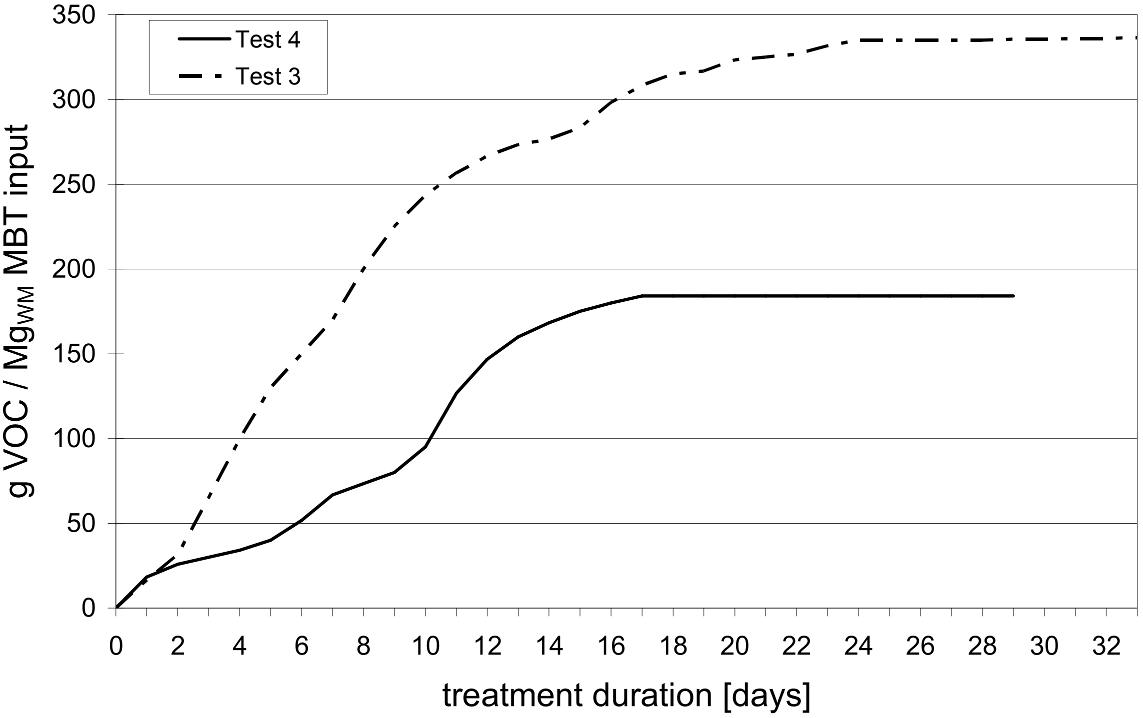


Figure 6 Specific VOC load of test 3 and 4 (related to MBT input, not to tunnel input!)

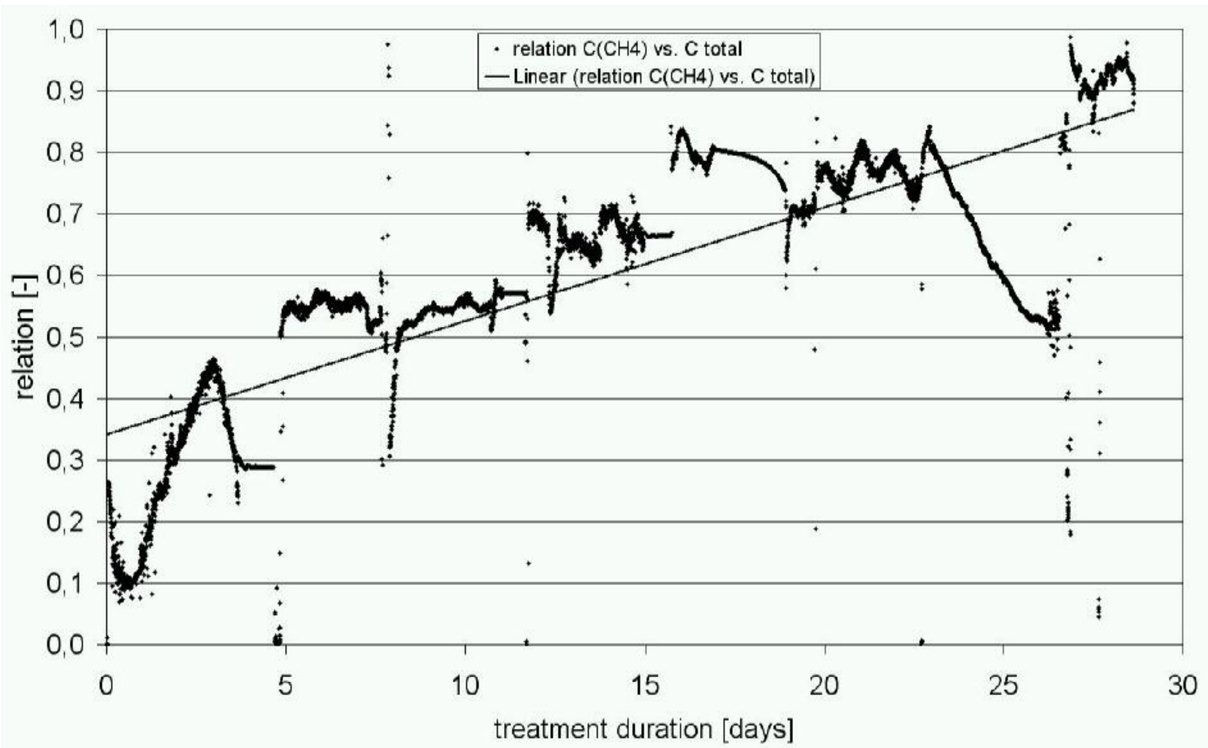


Figure 7 $C(CH_4)$ / VOC ratio test 4

Table 4 VOC load and concentration, air volume (dry, standard conditions)

Period		Complete test		until AT_4 <= 20mg/gDM	
Test		3	4	3	4
Start-AT_4	mgO_2/gDM	79	41	79	41
Input MBT ca.	Mg	35	51	35	51
Input Tunnel	Mg	22.8	27.7	22.8	27.7
Treatment duration	h	779	687	474	300
Treatment duration	weeks	4.6	4.1	2.8	1.8
Total volume exhaust gas	m³	29,144	11,918	21,599	10,526
Total VOC-load	gC	11,731	9,352	11,278	7,873
Average VOC- concen-tration	mgC/m³	403	785	522	748
Related to MBT-input					
Exhaust gas / Mg	m³/Mg	833	234	617	206
Exhaust gas hourly / Mg	m³/Mg*h	1.07	0.34	1.30	0.69
Total-VOC-load / Mg	g/Mg	335	183	322	154
Hourly VOC-load / Mg	g/Mg*h	0.43	0.27	0.68	0.51
Related to tunnel-input					
Exhaust gas / Mg	m³/Mg	1,279	430	948	380
Exhaust gas hourly / Mg	m³/Mg*h	1.64	0.63	2.00	1.27
Total-VOC-load / Mg	g/Mg	515	338	495	284
Hourly VOC-load / Mg	g/Mg*h	0.66	0.49	1.04	0.95

Masses in wet matter; exhaust gas volume standardised, dry

4.3 Laughing gas and ammonia

In test 4 ammonia and laughing gas were also measured.

Ammonia (NH_3): The test started with higher concentrations in the first four days. Another period of higher NH_3 concentrations was between the 10th and the 16th day with a peak of 1,300 mg/m³ (Figure 8). The majority of the NH_3 load was emitted between days 2 – 9 and 14 – 17 (Figure 9).

Laughing gas (N_2O): Relevant N_2O concentrations were only found at the first and after the 24th day (Figure 8). The high values after the 24th day were meaningless, because the tunnel was run nearly completely with recirculation air that time and almost no load was emitted (Figure 9).

The total load of N_2O and NH_3 per Mg MBT input is shown in Figure 10.

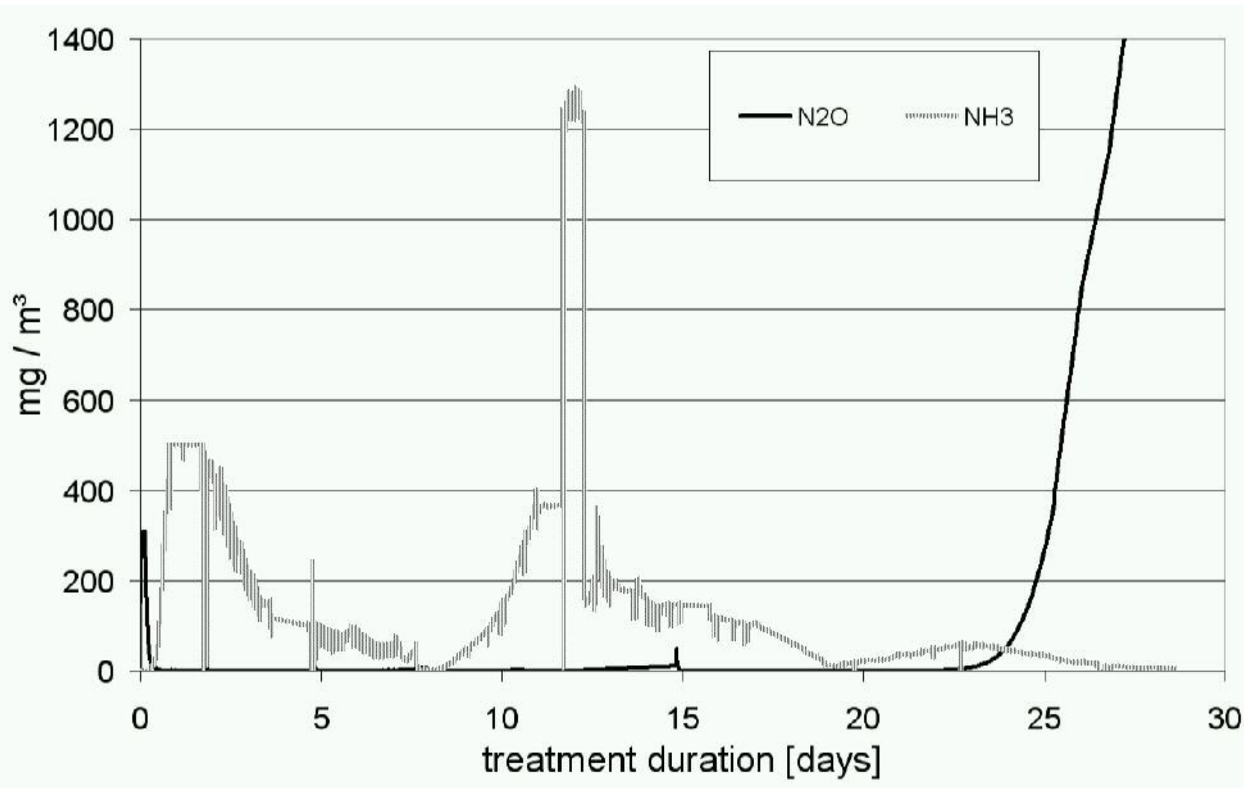


Figure 8 VOC, N_2O and NH_3 concentration at test 4

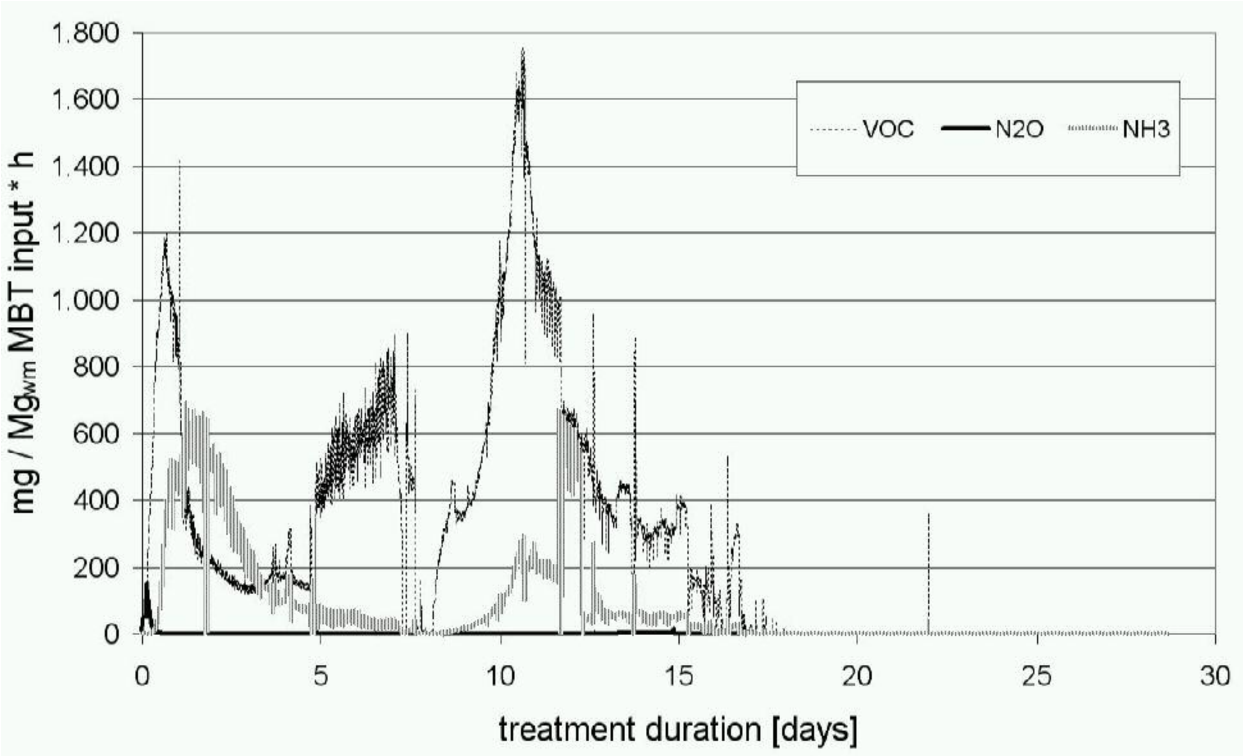


Figure 9. VOC, N_2O and NH_3 specific hourly load at test 4

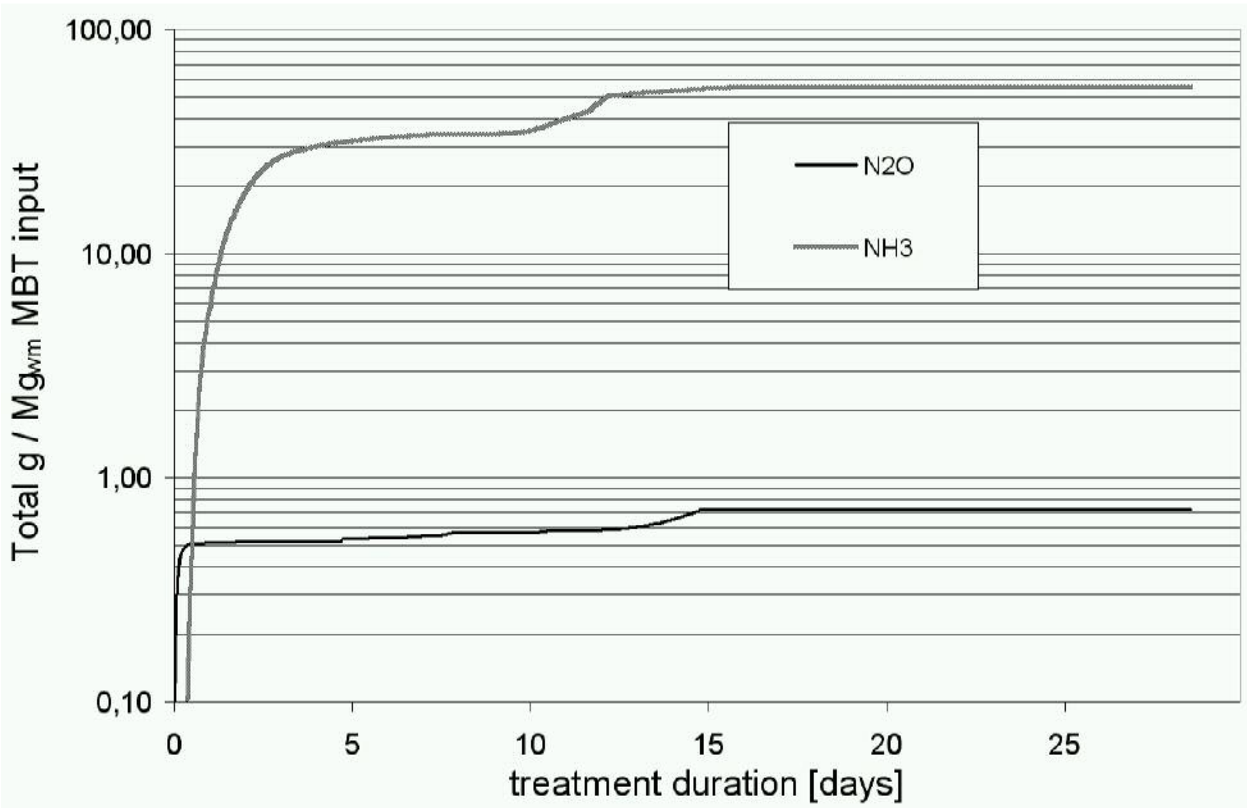


Figure 10. N_2O and NH_3 load at test 4

Finally it has to be mentioned, that all measurements represent the special conditions with the local waste composition and a very efficiently run composting tunnel operating with low oxygen content in the exhaust gas. Biological treatment in spacious halls with high oxygen contents in the exhaust gas and not at least locally different waste would have very different results.

5 References

Kuehle-Weidemeier, M.; Doedens, H.	2003	Landfilling and properties of mechanical-biological treated municipal waste. SARDINIA 2003, Ninth International Waste Management and Landfill Symposium, S. Margherita di Pula (Cagliari, Italy).
Stockinger, J.; Doedens, H.	2003	Air management and emission control at mechanical biological waste treatment plants (MBT). SARDINIA 2003, Ninth International Waste Management and Landfill Symposium, S. Margherita di Pula (Cagliari, Italy).

Author's address

Dr.-Ing. Dipl.-Geogr. Matthias Kuehle-Weidemeier
Wasteconsult international
Robert-Koch-Str. 48 b
D-30853 Langenhagen
Germany
Phone +49 511 23 59 383
kuehle @ wasteconsult.de (remove blanks)
www.wasteconsult.de


Altlasten
mechanisch-biologische
Abfallbehandlung
Geotechnik
Deponien
wasteconsult
INTERNATIONAL
Dr.-Ing. Matthias Kühle-Weidemeier
www.wasteconsult.de
Beratung
Pilotversuche
Planung
Ausschreibung
Bau- und Betriebsüberwachung
Robert-Koch-Str. 48 b
30853 Langenhagen
Tel. 0511 23 59 383
FAX 0511 23 59 384
info@wasteconsult.de