Milos Martinec, Eberhard Hartung and Thomas Jungbluth, Hohenheim

Biofilter

Influence of different filter materials on efficacy

In order to test the influence of filter materials on the efficacy of biofilters, five different filter materials were tested in parallel in a feeding pig building. The highest reduction in odour of about 81% was determined for the filter materials Biochips and coconut fibre peat.
All filter materials also reduced the emission of ammonia by on average from about 9 to 30%. The biofilter material Biochips offered substantially less flow resistance and electricity consumption compared with the other materials.

Dipl.-Ing. Milos Martinec is studying for his doctorate, Dr Eberhard Hartung is scientific assistant and Prof. Dr. Thomas Jungbluth is director of the special department Procedural Technology in Livestock Production and Building, Institute for Agricultural Engineering, Hohenheim University, Garbenstr. 9, 70599 Stuttgart.
This work was carried out within the framework of the DFG graduate lecture series:"Strategies for the avoidance of climate-relevant gases".

Refereed paper for Landtechnik the full-length version of which can be found under LANDTECHNIK-NET.com

Keywords

Biological air purification, biofilter, filter material, flow resistance

Literature details are available from the publishers under LT 00205 or via Internet at http://www.landwirtschaftsverlag.com/landtech/local/fliteratur.htm

Odour emissions from farm livestock production can be reduced by around 25 to 95% through biolfilters. At the same time the ammonia emissions are reduced (around 0 to 35%). The application of biofilters in conventional farms is, however, associated with very high running costs [3, 5, 6]. For this reason biofilters are only applied when the minimum distance is less than that stipulated by VDI 3471 [9] and VDI 3472 [10] or 'TA-Luft'. Through choosing the right filter material, there is a good chance of optimising biofilter effect.

The target of the investigation presented here was to determine the odour-reducing effect of selected filter materials. The influence of the filter material on the extent of emission reduction of NH_3, CO_2, CH_4, N_2O, on the flow resistance, and the electricity consumption were also tested.

Material and methods

Five biofilters of enclosed design (half technical scale) were fitted into research housing for feeding pigs from the seventh to the 22nd calendar week of 1999 [4]. The individual biofilters (2.19 m^2 ground area) were filled in each case with a 0.5 m high layer of the following filter materials:

- Biochips (Roth GmbH, Oberteuringen)
- Coconut fibre peat (blend ratio 1:1)
- Bark chips (from spruce, bark:wood chips 1:1)
- BioContact filter pellets + bark (34 cm + 16 cm)
- Biocompost (compost sieve size > 25 mm).

The exhaust air from the ventilation shaft of the house was channelled and led to an air separator. With the help of five radial fans the air was blown into the individual biofilters through the filter material from the bottom upwards and finally led out of the biofilters through an exhaust chimney on top. A measurement recording program controlled the measuring points commutator for gas analysis, the activation of the radial fans and the data recording (gas concentrations, volume flows, air temperatures, air moisture contents, electricity and water consumption). In a 20 minute measuring cycle, the NH_3 and CO_2 concentrations, in each case before and after the individual biofilters, were measured with two NDIR gas analysers. Before every single measurement cycle a new rated value for the participating volume flows of the individual biofilters was calculated from the actual exhaust air volume flow out of the building. With the help of PID regulators the radial fans were activated so that the volume flow, measured with calibrated measuring fans in the exhaust air shaft of the biofilters, indicated the pre-selected rated value. This approach meant that all biofilters were operated with an as far as possible identical filter load within a measurement cycle and, despite this, it was possible to be able to retain the typical daily exhaust air volume flow. Filter material was moistened to a chosen degree of wetness via a stick nozzle. Moisture content control was controlled by a moisture automatic which had had its moisture sensors calibrated in a pre-test with each individual filter material [7]. According to the draft of the European norm "Air quality – determination of odour concentration by dynamic olfactometry" [1] odour samples were taken twice weekly before and after each individual biofilter and analysed with an olfactometer TO7. Once per week, exhaust air and pure air samples were taken and the CH_4 and N_2O concentrations determined with a gas chromatograph.

Table: 1: Odour reduction of various filter material

	Biochips	Coconut fibre peat	Bark chips	Pellets+bark	Compost
Mean value [%]	81,3	81,6	62,4	60,4	65,9
Median [%]	85,2	86,1	69,3	63,4	69,0
Maximum [%]	95,4	96,7	88,9	90,7	93,0
Minimum [%]	44,8	31,6	- 4,2	- 9,1	28,2
Average filter volume load [$m^3 \cdot m^{-3} \cdot h^{-1}$]	613	529	558	618	473
Extent of variation of the filter volume load [$m^3 \cdot m^{-3} \cdot h^{-1}$]	139 - 1247	163 - 783	162 - 813	227 - 896	205 - 775
Total measured values	36	37	37	36	35

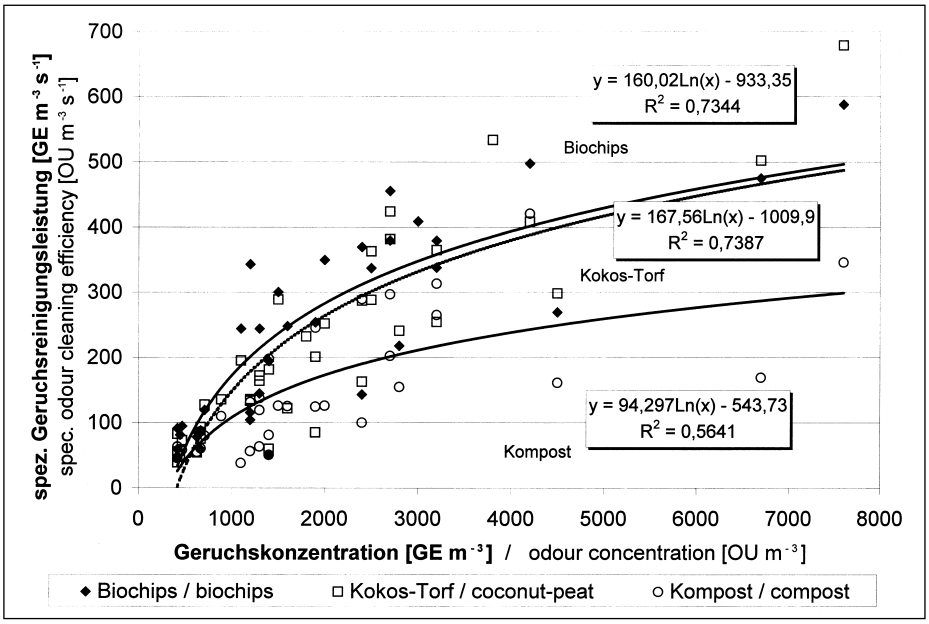

Fig. 1: Relation between the specific odour cleaning efficiency and the odour concentration in the waste air

Results

Substantial differences were determined between the individual filter materials in degree of odour reduction (table 1). The highest average odour reduction of around 81% was achieved by Biochips and coconut fibre peat. The lowest reduction was around 32%.

Determined with all the filter materials was a positive linear relationship between the specific odour-reduction performance and the specific odour load [Ge $m^{-3}s^{-1}$]. The odour concentration in the exhaust air (before the filter) represented the main influence factor on the extent of the odour reduction performance [3,6] which is presented in fig. 1 using the example of three filter materials. The rising filter volume load under the given investigation conditions had no decisive influence on the odour reduction performance.

The average ammonia reduction over the total trial period varied for the individual filter materials between 9% (Biochips) and 33% (compost). As already described in [3] the ammonia separation was reduced in line with rising filter volume load.

CO2 reduction took place with all the filter materials and varied in the total trial period between -5 and 5%. The calculated mean for the individual filter materials over the total trial period indicated a CO_2 production of around 0.1 to 0.7% and this was caused by biochemical oxidation [2].

The mean CH_4 reduction varied between 8% (Biochips) and 14% (compost) with an average emission rate (exhaust air) of 3.7 to 4.6 g/h. The mean N_2O reduction varied from -115% (compost) to 4% (Biochips) with an average emission rate (exhaust air) of from 0.12 to 0.135 g/h. The high N_2O concentrations measured after the compost filter material were caused possibly through anaerobic processes. However, because these mean values were calculated from 10 to 12 individual measurements only, a more precise statement on reduction/production is at the moment not possible. Only trends can be depicted.

Fig. 2 indicates the amount of flow resistance (mean, minimum and maximum) and the measured reduction of the filter materials in relation to the time of the trial with a filter volume load of 600 [$m^3m^{-3}h^{-1}$]. According to [11] this is the maximum advised filter volume load for coconut fibre peat.

The least flow resistance was determined for the roughly-structured filter materials Biochips (around 18 Pa) and pellets/bark (around 55 Pa) and these stayed constant throughout the entire trial period. Contrary to this, the flow resistance rose to as much as four times more for the remaining fine-structured filter materials. This was mainly caused by the sizeable reduction in the height of the filter materials through their own weight and the collection of dust in the filter material. Additionally, the material moisture content in the fine-structured filter material had an influence on the varying extent of the flow resistance. After filter material is moistened the small pores between the individual particles fill with water which leads to a substantial rise in the flow resistance.

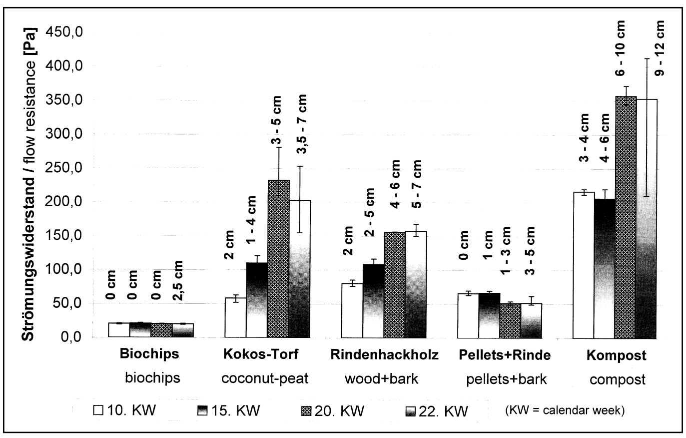

Fig. 2: Flow resistance and lowering of various filter materials during the experiments

The specific filtering performance [W/1000 m^3 of expedited air] in the last three weeks of the trial was around 30% less for Biochips compared with the coconut fibre peat. This applied only for the radial fans used in the trial. For all the other biofilter plants, the filter performance has to be calculated anew from their air throughflow and the appropriate flow resistance of the plant as well as the fan performance characteristics.

Conclusion

In the application of a new filter material (Biochips) the same reduction in odour (around 81%) can be aimed for as with the mix of coconut fibre and peat which is often used in practice. On the other hand, the Biochips were distinguished through a notably reduced flow resistance which led to a reduction in the running costs (electricity costs). Further continuous investigations into the influence of the filter materials on the emissions of CO_2, CH_4, N_2O are to be carried out. In a further trial, Biochips laid at 1m deep were tested and this was able to lead to a reduction in the buildings costs (reduced area requirement). An evaluation of the economical viability is to be publicised in a subsequent report after completion of the investigations.