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Economic evaluation of biofilters

Two filter materials and different building designs were tested in parallel for the optimising of biofilters for odour reduction from feeding pig housing. Average odour reduction was from 70 to 80%. Factors with the most influence on this reduction were raw air odour concentration and filter material moisture. The application of rough-structured materials such as biochips allowed higher pile heights and filter volume loading and this reduced investment costs. At the same time this over-proportionately increased airflow resistance and thus running costs. This is an important point when considering the planning of a biofilter and the associated total costs.

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Keywords

Biofilter, filter material, flow resistance, costs

As already established in previous long-term investigations, using a new filter material (biochips – roughly-chopped coconut shells) can result in the same reduction in odour (~ 81%) as the coir-peat mix often used in practice. However, with a pile height of 0.5 m, using biochips resulted in substantially-reduced airflow resistance, and thus running costs, compared with coir-peat [1].

Aim of this investigation was to determine odour reduction capacity and airflow resistance of selected filter material and filter designs with the target of using results for a recommendation on biofilter construction and design (through planning examples for so-called demonstration biofilters) for odour emission reduction from farm animal housing and also to help in economic evaluation of the investigated variants.

Materials and method

Five closed construction biofilters (semi-technical scale) were connected to feeding pig trial housing from 8.7.1999 to 7.2.2000 [2]. The design used for the individual biofilters (2.19 m^2 ground area), height of pile, and filter material used, are all given in table 1. Biofilters 1 and 2 as used in the previous investigations between 19.2 and 4.6.1999 [1] continued in operation without any changes.

The arrangement of the individual measurement points in the „downstream" and „upstream" design is given in the full-length edition (see LANDTECHNIK-NET.com). The facility control and comprehensive oversight of the measurement equipment used is included in [1].

Results

In-part, substantial differences in *odour reduction* were determined between the individual biofilters. In the first eight trial weeks of the trial especially, it was observed that biofilters 3, 4 and 5 reduced odours to a lesser extent. This was probably due to the population of micro-organisms in the filters not yet being fully developed during the starting period because, as the trials proceeded, the difference between the individual biofilters because notably less and produced a more efficient and less deviating odour reduction performance during the total investigations compared with the results from biofilters 1 and 2 in the main phase of the first trial. The variants' calculated average odour reduction showed hardly any difference with biochips (69.6%) and coir-peat (70.1%). With the downstream variants the highest average reductions of 73.3 and 75.5% could be achieved (*table 2*). Filter number 5 gave the

Table 1: Set up of experiment

Biofilter Nr.	Filter material	Pile height in m	Construction type
1	biochips *	0,5	upstream
2	coir-peat*	0,5	upstream
3	biochips	1	downstream
4	biochips	1	downstream
5	biochips	1	upstream

* Continuation of previous investigation

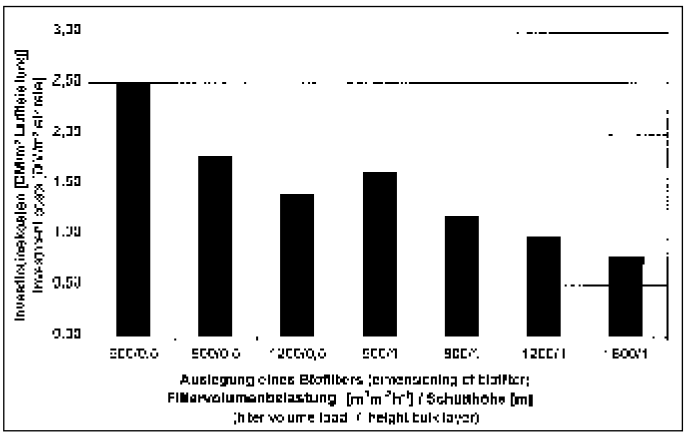

Fig. 1: Investment costs of different dimensioning example biofilters (standard equipment) filled with biochips for 400 fattening pigs

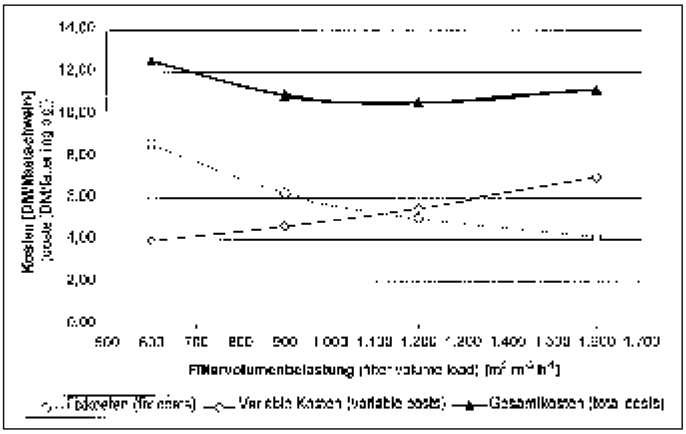

Fig. 2:Development of costs depending on filter volume load of example biofilters (standardequipment) filled with biochips for 400 fattening pigs

lowest average reduction of 57.1%. Not counting the one negative result, a minus of 42% probably due to an evaluation mistake, average odour reduction in filter 5 was 61.5% (*table 2*). On average, odour reduction by filter 5 was around 15 to 20% lower than the other variants (1, 3 and 4) which could have been caused by less water consumption and a higher proportion of dry areas in the filter material compared with the others. In total, the results showed that an increasing concentration of odour in raw air resulted in an improvement in odour reduction with all variants, and that the filter volume loading had no absolute influence on the odour reduction.

For *cost estimations of biofilters* with different layout a special data page was installed in Excel into which could be entered stocking rate, temperature zone (DIN 18910), maximum filter volume loading, pile height, price of individual constructional phases, building components plus power and water inputs. Necessary filter area and filter volume as well as the resultant fixed costs [3, 4] could then be calculated on the basis of this data. Regarding calculation of electricity costs associated with the running of the respective „demonstration filters“, data collected in own investigations enabled identification of exhaust air volume flow or filter volume loading for the respective average flow resistance of the filter material in each case and to that was added the flow resistance of central extraction according to estimated (on expected values) flow resistances.

Thus, on a typical house with 400 feeding pigs different layouts of biofilter filled with biochips and with standard equipment were compared for investment costs (*fig. 1*). Through increasing the filter volume loading from 600 m^3 to 1600 $m^3 \cdot m^{-3} \cdot h^{-1}$ the area of the biofilter could be reduced from 112 m^2 to 21 m^2 and thus the investment costs for a biofilter by more than a factor of three (from 2.49 to 0.80 DM • m^{-3} installed air capacity). The estimated investment costs for the two highest loaded variants were under those determined by [3] and [5]. With the planning of the filter volume loading of 600 $m^3 \cdot m^{-3} \cdot h^{-1}$ and a pile height of 1 m the investment cost rose in comparison to the previous variants with 1200 $m^3 \cdot m^{-3} \cdot h^{-1}$ at 0.5 m in that, with the same filter area (56 m^2), a deeper soil excavation, higher walls for the filter container and double the amount of filter material was required. Along with fixed costs, variable costs, especially those for electricity, are also interesting (*fig. 2*). Fixed costs can be reduced from around 8 to 4 DM through an increase in the filter volume loading by a factor of around 2.7. The filter material flow resistance increases in line with this and thus the electricity costs responsible for the increase in variable costs from around 4 to 7 DM. Total costs sink in line with rising filter volume loading but reach their minimum at around 1100 to 1200 $m^3 \cdot m^{-3} \cdot h^{-1}$ (~ 10.60 DM). Along with this, the potential of the filter material based on the high absorption and microbial degradation rate, which would also allow a higher filter volume loading [3, 5], cannot be fully exploited.

Table 2: Odour reduction of examined filter materials and construction

Biofilter Nr.	Biochips (1)	Coir-peat (2)	Biochips (3)	Biochips (4)	Biochips (5)
Average [%]	69,9	70,1	73,3	75,5	(57,1) 61,1*
Median [%]	67,8	69,0	78,2	80,6	(68;9) 68,9*
Min [%]	41,7	50,6	40,0	33,3	(-42,6) 20,6*
Max [%]	91,9	91,1	94,9	94,0	(87,9) 87,9*
Standard deviation [%]	13,9	10,9	14,4	14,9	(28,9) 20,5*
Standard error of the Average [%]	2,8	2,2	2,9	3,0	(5,9) 4,3 *
Number of samples [n]	24	24	24	24	(24) 23*

* Values were calculated without the non-recurring value (measurement error) of -42.6%

Summary

In part, odour reduction performance differences were able to be established between the different filter materials and constructions, although these were ultimately traced in the main to the uneven moisturisation of the filter material. Through application of a new filter material (biochips) the same level of odour reduction can be achieved as with the coir-peat mix commonly used in practice. However, the filter material influenced to a great extent the airflow resistance in the biofilter and thus the variable costs (electricity costs). In planning a biofilter attention must be paid to achieving an optimum relationship between dimensions and total costs. Further investigations should be aimed at checking which times of operation for the biofilters with rough-structured filter material such as biochips can be achieved without any important worsening of odour reducing performance.

Literature

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