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Dust Filtration through Applying Renewable Resource Material

Reducing dust in animal house air by filtration can be applied as a measure for improving the environment in pig keeping. The question on whether renewable raw materials are suitable as filter materials was investigated. The results demonstrate good filtration efficiency, as well as good composting features.

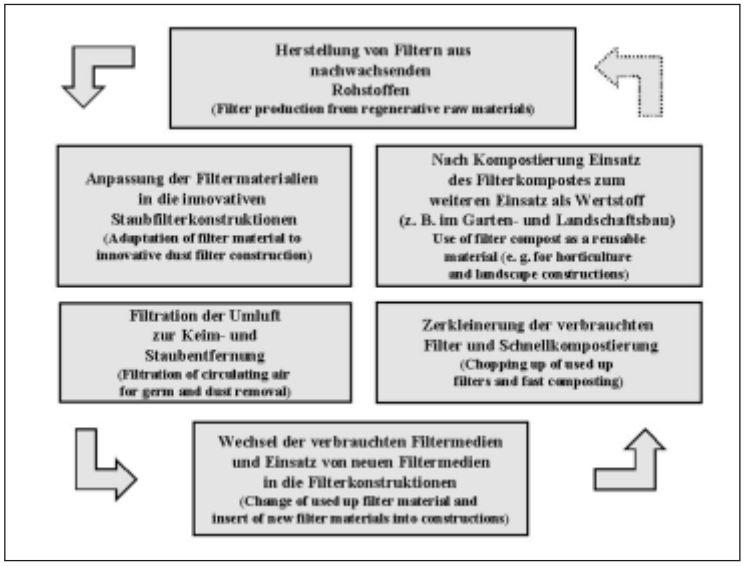

Fig.1: Cycle of applied filter materials

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Keywords

Pig keeping, animal house dust, germs, hemp, flax, air hygiene

Literature

[1] *Done, S.H.*: Environmental factors affecting the severity of pneumonia in pigs. Vet. Rec. 128 (1991), pp. 582-586
[2] LAGA: Mitteilungen der Länderarbeitsgemeinschaft Abfall, Merkblatt M 10 über Qualitätskriterien und Anwendungsempfehlungen für Kompost, Erich Schmidt Verlag GmbH & Co., Berlin, 1995

The stable climate plays a determining role in view of health and performance of productive livestock kept in stable buildings. In addition to adjusted air temperature, optimised humidity and carefully controlled air circulation dust pollution should be as low as possible. Additional health-legally harmless jobs are to be guaranteed for the persons working in stables.

Especially feed, which is influenced by its composition and the kind of feeding, as well as the bedding and the whirl up of already sedimented particles are sources of dusts in stables. Particle size distribution and concentration in the stable are determined by the number of animals, the animal weight and the animal activity. Higher concentrations of dust appear during the day, because of feeding and disturbance of the animals (e.g. by controls), than in night times or in quiet periods. As a result high deviations of particle concentration can be noticed in the course of the day and of the year.

Therefore a total system solution had to be developed which is able to minimise dust problems in animal houses by means of regenerating raw materials. The following investigations should be designed according to a substance cycle of the filter material, which is shown in *Figure 1*. This material cycle makes the internal composting and use of the used up filter material possible.

Material and methods

Recording total dust
For measuring total dust a gravimetric procedure was used. Dust was recorded by means of a pump, which pushes air through a filter (3,5 lit/min). Afterwards the fine filter was weighed and related to the air flow.

Recording total aerobic germ number
AGI-30 Impinger
An air stream is led through a special washing bottle for a definite time. In the bottle is a nutrient solution. Vacuum flow was 12,5 lit/min. A high elimination is achieved by very fine porous nozzling of air in the washing bottle. The Impinger bottles were packed sterile until use.

Composting
Laboratory test to the compost quality were accomplished following the „Methodenbuch zur Analyse von Kompost, Bundesgütegemeinschaft Kompost e.V“ì

Stable unit and filtration construction
Investigations were carried out in a flatdeck section with 12 boxes, in which 25 stores per box were housed. The ventilation system of the stable was designed as an extraction ventilation with trickle ceiling. The size of the stable was 310 m^3.

Table 1: Tested filter materials

Filter	Material and thickness
Type 1 (Coarsefilter)	Flax fleece 7 mm
Type 2 (Fine filter)	SEK reinforcement mat with jute carrier structure, 30 % sisal, 70 % hemp, 5 mm
Type 3	Mix of hemp fibres with a polypropylene supporting-tissue, 60 mm

Table 4: Valuable properties and ingredients of different composts

Parameter	Compost 1	2	3	acc.to LAGA-Merkblatt [2]
soluble salt content (g/l)	3.6	4.8	3.7	2-8
pH-value	7.4	6.9	6.8	7.0-8.3
Nitrogen (total N) (% DM*)	0.46	1.15	0.86	0.8-1.5
Phosph. (P_2O_5 soluble, mg/l WM*)	547	675	663	500-2000
Pot. (K_2O soluble) in mg/l WM	1094	1176	1143	1000-5000
Vegetable tolerability (%)*	108	103	101	100

*DM: Dry matter WM: Wet matter

The dust filtration construction was fixed in the section and worked independent from the existing ventilation system on the principle of circulating air. The dust loaded air from the section was sucked in on the one side and afterwards is passed through two filter cassettes. The filter of the first cassette was coarse fleece, while in the second cassette a fine fleece material was used, in order to filter small dust particles, too. The cleaned air reached the exit through the ventilator and was distributed in the room again.

Filter media and ventilator power

For the first test a coarse and a fine filter were used. The second and third tests were carried out with only one filter cassette (one filter). This filter was much thicker and a mixture of hemp fibres with a polypropylene supporting tissue, which is normally used as an insulation material. Materials and dimensions of filters are shown in *Table 1*.

The air filtration construction was designed according to the following specifications.

- 315 mm radial pipe ventilator
- Conveying air flow max. at 250 Pa resistance: 1.300 m^3/h
- Power max.: 285 W
- Power control: 0 -100 % variable

Results

Table 2 shows the dust concentration, measured during the three tests at the entry and the exit of the filtration construction. All tests show efficiencies of more than 60 %. The highest efficiency (81 %) was measured on 19. 11. 2003. In literature, reference values of 1 mg/m^3 total dust were found [1]. By means of the developed filtration construction this reference value can be lower (*Tab. 2*) and therefore contribute to a minimization of the dust load for the animals.

By reducing the dust concentration in the stable air the number of aerobic germs could be decreased, too. Efficiencies up to 96 % could be observed (*Table 3*). A limit for the reduction of pneumonia of 10.000 KBE/m^3 is given by literature [1].

By means of air filtration concentrations could be still reached below this value. The composting of the hemp or flax fiber filters shows a very sensible alternative to the disposal of customary filters from synthetic materials. Waste from natural fibres can be easily supplied to composting. The used filters in the stable, which are 100 % natural fibre (hemp) belong therefore to the suitable biofilters.

With the proper composting, which is accompanied by a temperature rise in the compost and by a considerable increase of the micro-organisms which decompose the organic substance. Pathogens are killed, too. The destruction of pathogens, germinable vegetable parts and seeds depend on several factors (resting time, temperature influence, application of technical procedures etc.). Good compost quality is characterised by a high nutrient content, low heavy metal content and hygienic safety.

The finished compost was therefore examined after certain quality criteria. It was shown that the test criteria are usually fulfilled and composts show good quality (*Table 4*). Only pH-values were at the lower limit.

Date	Entry [mg/m^3]	Exit [mg/m^3]	Efficiency of facility in %
22. 10. 2003	1.7	0.5	71
12. 11. 2003	3.6	1.4	61
19. 11. 2003	2.6	0.5	81

Table 2: Recording dust concentrations

Date	Entry [KE/m^3]	Exit [KE/m^3]	Efficiency of facility in %
22. 10. 2003	42000	1500	96
12. 11. 2003	150000	23000	85
19. 11. 2003	98000	13000	87

Table 3: Aerobic total germ number (KE/m^3)

Total nitrogen content of Compost 1 is comparatively small. Causes for this can be the too high quantity of admitted fibre material to the compost 1, because due to the wide C/N ratio of hemp (80:1) 10 l liquid manure is apparently not sufficient to adjust the lack of nitrogen caused by the hemp. Similarly it is with the increased plant-available nitrogen of the compost substrate 2. Also here it attention must be paid during the composting to the fact that the ratio of liquid manure to the other components, which can be added, is correct, concerning the nitrogen supply.

Summary

The integration of an autonomously working dust filtration construction into an existing stable showed very promising results. The investigations concerning the minimisation of dust pollution by filters made from renewable resource materials point to a good filtration performance. Efficiencies of about 80 % can be attained. At the same time a reduction of dust concentration by 45 % inside the stable can be obtained. Additionally to the reduction of dust the number of microorganisms in the stable air could be decreased, too.

The quality of the compost produced, which exists of biologically degradable filter materials is essentially in the range of claimed criteria for compost. Quality criteria demanded can be achieved despite variations by specific compost compostion.

The following aspects have to be investigated in subsequent tests. Filter materials which are the best suitable materials for dust filtration were hardly bio degradable because of their content of polypropylene. This structure material is essential for maintaining the required filter thickness and for reducing the filter changing times. So a filter would have to be developed which contains a bio degradable structure material, for instance potato starch. However, this is an independent, complex subject which couldn't be solved within the given time of the project.