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In-barn sources of polluting gas emissions

Wind canal measurements for quantitative determination of polluting gas emissions in forced ventilated feeding pig housing

To achieve exact results on barn emission behaviour an analysis of individual in-barn emission sources is required. In this context, knowledge of pollutant gas emission quantities from individual emitting areas is to be seen as the basis for limiting emissions. An important aspect in the determination of individual emission sources is the choice of a reproducible measurement method. A wind canal was used for investigating different areas in feeding pig barns under practical conditions.

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Keywords

Emission sources, green house and eco-relevant gases, floors

As basis for determination of pollutant gas emissions and the resultant actions towards minimising them from forced ventilation feeding pig housing own trials took a closer look at individual in-barn emissions. Parallel to this, continuous measurement was conducted in the exhaust airshafts for ammonia (NH_3), methane (CH_4), carbon dioxide (CO_2) and nitrous oxide to determine the total emissions.

Regarded as emitting areas in the barn were the lying area, dunging area, the feed trough, the equipment, the barn passage and the animals themselves.

According to [1] the pen floor and the animals can be regarded as important emission sources.

Material and methods

For measuring trace gases from the entire barn as well as from individual areas an Innova Airtech Multigas monitor was used. Measurement fans determined air volume flow. The emission levels from individual emission surfaces in-barn were measured once weekly whereby two to three floor surfaces were sampled by wind canal in each case.

The wind canal area was 1 m^2. To achieve consistent winter (0.2 m/s) and summer (1.0 m/s) airflow velocities a radial fan was installed in front of the measurement area. Parallel to the recording method, all pens in the trial barn were assessed for dirtiness.

Measurement of animal emission levels was not possible in the trial situation described here. Instead, the difference between total barn emissions and those from individual sources was attributed to the animals. Considered here also was the assessment of the degree of dirtiness of the animals.

Three similarly constructed barns were used in the trials. These differed only in the type of lying area and form of slatted flooring (*table 2*).

The trial barns (VS) were in each case filled over 52 days for the prefinishing phase with housing at 25 kg lw and moving out at 65 kg lw. As a rule there is a three-day gap between feeding batches which are run on an all-in, all-out principle. The trial period ran from October 2001 to July 2002.

Selected results

The trials showed (*fig. 1*) that the level of emissions from slurry channel and solid floored lying areas varied very strongly in relationship with temperature.

During the investigations it was established that when comparing the different forms of housing VS III a (*table 2*) with concrete slats as lying area and also ecological slats came out best regarding cleanliness of pigs. Compared with this, in VS I a (table 2) a consistent dirtying of the roofed lying area could be observed in the first days after penning. This could be explained through the new environment and the altered group membership.

Much more problematical was the situation in VS IIa (table 2) where the assessed pens were marked by continuous dirtying that continued right through the prefinishing phase. Here, the reason could be the high proportion of completely closed flooring per pen. In later stages of the prefinishing phase it was determined that slat throughflow for dung was reduced. On the roofed lying area

Table 1: Summary of usable data on emission sources in pig houses

Source	Housing	Compartment in barn: Animal	Flooring Dirtied surfaces	Slurry
[1]	Model situation	19 %	45 %	36 %
[2]	Part slatted flooring			70 %
[3]	Fully slatted flooring	25 - 50 %		50 - 75 %
[5]	Full, part slatted flooring		50 %	50 %

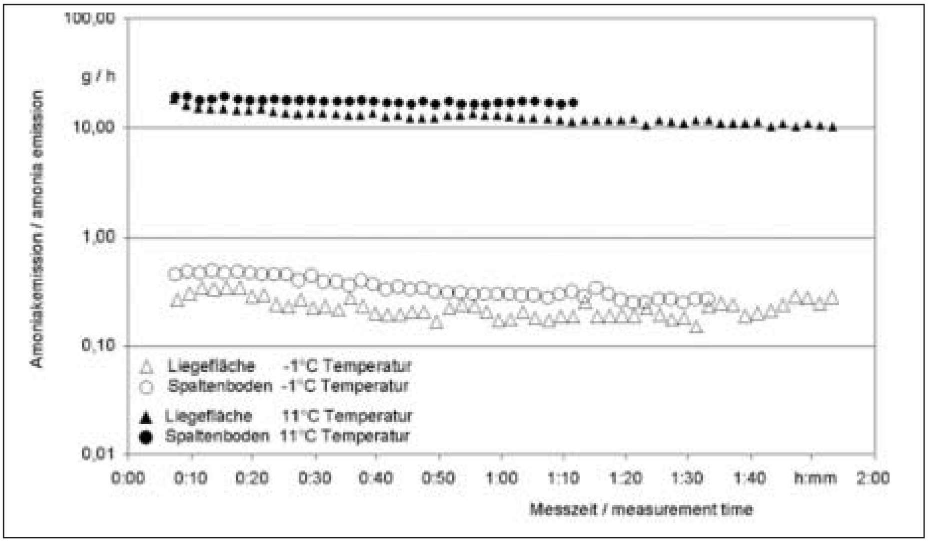

Fig. 1: NH_3 -emissions above pig house floors with different fresh air temperatures measured by a wind tunnel

Table 2: Floor variants of the test pig house with a pen size of 23,5 m^2

Trial building	Lying area Form	Part of slats (%)	Slot area Form	Area of slats (m^2)	Proportion of totally closed flooring/pen (%)
Stall I a	Type roofed	0	Moulted slats	3.22	86.3
Stall II a	Type roofed	0	Concrete slats	1.61	93.2
Stall III a	Ecol. slats/concrete	<10	Moulted slats	4.17	82.3
Stall III b	Concrete slats	12.7	Moulted slats	4.52	80.3

the pigs started dirt baths even at outer temperature of ~ 15°C whereby the emitting surfaces of the pen flooring as well as the animals themselves increased.

Misting trials showed that in VS IIa there was less air exchange between the slurry channel and the air area of the barn. Emissions from the slurry channel were appropriately low. This result was support through statements from [4 and 1] over reduced ammonia release where airflow velocity and turbulence were also reduced.

The applied ammonia measurement method showed concentrations in the area of 1 to 7 mg/m^3 air emitted. Around 75% of the measurement values lay in the range between 1 and 3 mg NH_3/m^3 air whereby all investigated floor types were included in the evaluation.

Outlook

As further work the emissions of the individual trace gases have to be determined so that a relative emission data comparison can be attempted for the individual emission sources. Here, special emphasis should be put on the different gases. One can assume that every gas depends on different factors for its release. For instance the length of storage time for under slat slurry would have a higher influence on methane release than the level of the slurry under the slats.

Floor type	Amount of slots/m^2	Size of slots in cm	Proportion of slots per m^2 in %
Moulted slats	43	1.7 x 36.5	26.3
Concrete slats	30	1.7 x 25	12.7
Ecological slats	22	1.7 x 25	9.4
Roofed lying area	5% slope		

Table 3: Floor types of the test pig house

Summary

The selected trial method allowed a reproducible investigation into emission sources inban and the trial equipment applied could be seen as suitable for the investigation in question. To what extent the method for calculation emissions from the animals can be seen as applicable has to be looked at in the context of a total evaluation. The temperature can be cited as an important emission-influencing factor.

Literature

[1] *Janssen, J. und K.-H. Krause* : Stallinterne Beeinflussung der Gesamtgasemission aus Tierhaltungen. Grundlagen der Landtechnik 37 (1987), S. 213-220

[2] *Hoeksma, P., N. Verdoes, J. Oosthoek and J.A.M. Voermans* : Reduction of ammonia volatilisation from pig houses using aerated slurry as recirculation liquid. Livestock Production Science 31 (1992), pp. 121-132

[3] *Christianson, L.L., R.H. Zhang, D.L. Day and G.L. Riskowsk* : Effects of building design, climate control, housing system, animal behavior and manure management at farm levels on N.losses to the air. In: Nitrogen flow in pig production and environmental consequences, edited by M.W.A. Verstegen, L.A. den Hartog, G.J.M. van Kempen and J.H.M. Metz. Pudoc, P.O. Box 4, 6700 AA Wageningen, Niederlande, 1993, pp. 271-279

[4] *Praetere, K. de and W. van Biest* : Airflow patterns and their relation to ammonia distribution. Land and water Use, 1989, pp. 1457-1464

[5] *Rom, H.B.*: Nitrogen flow and ammonia emission in fattening pig units. In: Gasanalytik in der Nutztierhaltung und Landwirtschaft, Berlin, 22.11 -23.11.1994