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Emission Factors in Turkey Fattening

Immission relevant permit procedures for new constructions and structurally altering naturally ventilated animal houses generally require dust, ammonia and odour emission quantification. Due to measurement difficulties only little data from naturally-ventilated animal houses is available. In spring of 2004, dust, odour and ammonia emission were measured in a naturally ventilated turkey fattening house. The results are presented in the following article

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For reasons of immission protection, permit procedures for the construction of naturally ventilated livestock houses or for the modernisation of existing ones usually demand quantified information on dust, ammonia and odour emissions. Due to technical difficulties in the corresponding measurements, there are only limited data available on such emissions from naturally ventilated livestock houses. Especially air volume flow rate measurements pose a technical problem in naturally ventilated livestock houses. Simple measuring methods such as the measuring fan method are not suitable in this context. For this reason, research at the Institute for Agricultural Engineering has used a proven tracer gas method using SF_6. An additional problem in naturally ventilated livestock houses is the choice of the right sampling point for concentration measurements. Due to the large ventilation areas and the varying concentrations on the interior, it is difficult to select representative measuring points.

Due to differing ventilation and flow scenarios, it is difficult to transfer the emission mass flow rates of mechanically ventilated buildings to the situation in naturally ventilated buildings. On the one hand, the type of ventilation used has a major influence on the conversion processes that are responsible for the formation of dust, ammonia and odours in a building; on the other hand, the emission characteristics at the emission point depend on the ventilation type as well.

Dust, odour and ammonia mass flow rates in a naturally ventilated turkey house were measured in the spring of 2004. The results are presented in this paper.

The barn used in the experiment

The measurements for this paper were taken in a conventional turkey house with natural ventilation. It is 125.2 m long and 16.6 m wide, with eaves 2.6 m high and a ridge 5.8 m high. There is a service room with a floor area of 18.6 m^2 partitioned off at the north end of the building. The floor area of the turkey house is 2,053 m$^?$, and its volume is 8,597 m^3.

Fig.1: Interior view of the experimental turkey house

The turkey house has a combined transverse and eaves-ridge ventilation system; according to the ventilation requirements, the blinds along both long walls can be lowered from the eaves down to 1.60 m to produce ventilation openings with a maximum height of 1.0 m. If the blinds are completely open, the resulting ventilation area per wall is 125 m^2, or 40 % of the whole wall area. In addition, the building has an adjustable ridge cap for variable ridge ventilation. At it's maximum, the ridge opening constitutes another exhaust air opening of approximately 76 m^2.

Approximately 6,600 turkey cocks are moved in at an age of 5 to 6 weeks. The birds are moved out 15 weeks later, weighing approximately 20 kg. The barn floor is littered with long wheat straw, with fresh straw being added approximately every other day. The three identical barns on the farm are operated in a 19-week production cycle.

The barn used in the experiment is set at right angle to the main wind direction, on the windward side of the group of three buildings. An approximately 2 m high hedgerow at a distance of 16 to 34 m is a minor obstacle to the free flow of air towards the building.

The next barn is approximately 20 meters away on the leeside of the experimental barn.

Measuring methods

The air volume flow was measured using the SF_6 tracer gas concentration decay method. This means that the gas supply is switched

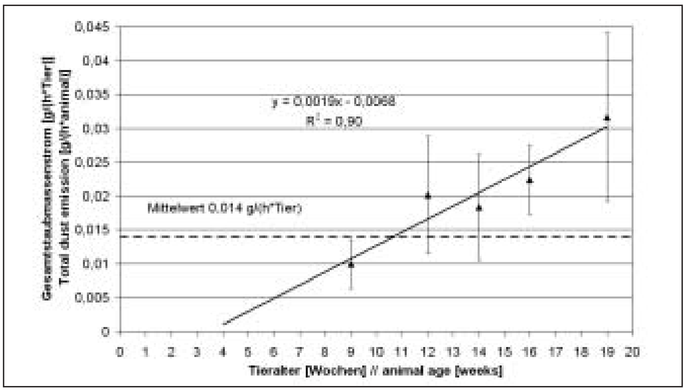

Fig. 2: Total dust emission from the turkey house

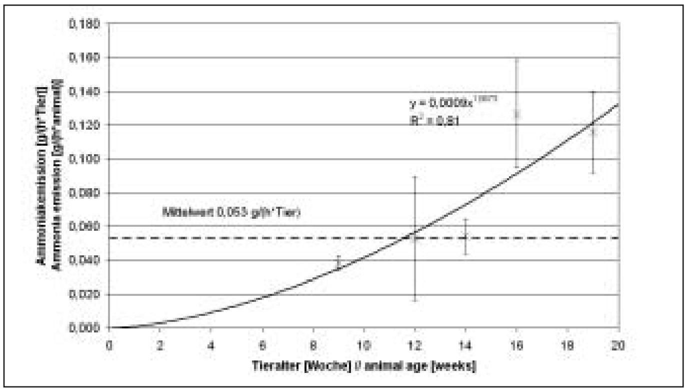

Fig. 3: Ammonia emission from the turkey house

off after a single dose of tracer gas. The exponential decaying behaviour of the gas concentration serves as the basis for calculating the air volume flow rate. Detailed descriptions of this method can be found in [1, 2]. For validation purposes, this method was compared with the measuring fan method in a mechanically ventilated barn [2]. The concentration decay method is not a continuous measuring method. Accordingly, one emission value was determined for each measuring period.

The dust concentration in the exhaust air was measured with a Model 1.108 aerosol spectrometer from GRIMM Aerosol Technik, Ainring, Germany. This spectrometer works according to the light scattering principle. A gravimetric factor, which had been determined in experiments beforehand, was used to convert the particle number concentration into particle mass concentration. The ridge opening was chosen as the measuring point, because of the continuous flow of exhaust air through the opening. All samples were taken isokinetically, adjusted to the exhaust air flow speed.

The ammonia concentration measurements were carried out as point measurements using a portable Dräger CMS (chip measuring system) simultaneously with the air change rate measurements.

The measuring principle of this system is based on the colour change in a reagent system, which is detected with an optical sensor. The air samples used in the experiments were composite samples from the ridge opening.

Also simultaneously, further composite exhaust air samples were taken from the ridge opening by means of a vacuum pump. An experienced panel at the Institute of Agricultural Engineering analysed the samples, using a TO8 olfactometer by Ecoma.

Results and discussion

The measurements were carried out over the course of one fattening period between March and June. The ventilation principle during this period was eaves-ridge ventilation. The measured air volume flow rates ranged from 35,000 m^3/h when the turkeys were in the ninth week of their lives to 300,000 m^3/h in the nineteenth.

The results of the dust measurements are presented in *Figure 2*. The daily averages of the total mass flow rates of dust increased with the age of the turkeys. One reason is that the air volume flow increases with animal age. Animal activity was seen to increase with age as well, which results in more dust particles being dispersed. Based on 2.7 fattening periods of 20 weeks each per year, the dust emission factor was calculated to be 127 g/(animal place•year). Averaged over a whole fattening period, the measured mass flow rate of 92 g/h is well below the 200 g/h ceiling for total dust emissions defined in the Technical Instructions on Air Quality Control (TA-Luft).

Animal age has an influence on the ammonia emissions as well. *Figure 3* shows the development of the ammonia emissions from the turkey house. For 2.7 fattening periods of 20 weeks each per year, the ammonia emission factor is 480 g/(animal place • year). This is well below the ceiling of 728.6 g/(animal place•year) for turkeys, defined in the Technical Instructions on Air Quality Control (TA-Luft).

The results of the odour measurements are presented in *Table 1*. The daily averages are in the range commonly reported for turkeys in the relevant literature [4]. The average emission rate for the whole turkey house is 2046 OU/s.

The results presented here are all based on measurements carried out during one fattening period between March and June. Therefore, they are not suitable as a basis for calculating emissions over a whole year. However, they highlight the great variability of the emissions in the course of the fattening period, and they characterise the emission situation in the in-between season.

Conclusion

The emission mass flow rates during the fattening period were highly variable. Animal age in particular has a crucial influence on the development of the mass flows. Simple averages and emission factors alone do not do justice to the actual emission processes. A precise description of emissions - especially in poultry farming - must take their development over the entire fattening period into consideration. With regard to permit procedures, constant emission factors are not very realistic as benchmarks for assessing buildings. For a more precise description of the emissions from livestock houses it will be advisable in the long run to use characteristic factors such as animal type, animal age, season, and litter type for modelling the relevant processes in livestock buildings.

Animal age [Weeks]	odourant concentration [OU/m^3]	Volume flow rate [1000 m^3/h]	odour emission [OU/(LU • s)]	odour emission [OU/(animal • s)]
9	87	63	23	0.23
12	61	166	27	0.43
14	66	143	18	0.40
16	51	224	19	0.48
average, integrated over the fattening period				0.31

OU: odour unit
LU: large animal unit, equals 500 kg live weight

Tab. 1: Odour emission from the turkey house