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Gas Emissions from Poultry Houses – a Long-term Examination

Animal house ventilation causes air-borne pollution in the surrounding area. To determine gas concentration around stalls with numerical models and to develop ventilation systems with a low emission mass flow, knowledge about emission mass flows from livestock buildings are necessary. Based on this aspect, a broiler house and a lying hen house were examined.

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Compliance with the livestock housing climate parameters required for animals in the standard bodies of rules and regulations (in Germany for instance in DIN 18910 "Thermal protection of closed livestock housing") calls for sufficient ventilation of the houses. This necessarily leads to emissions of gases, odours, dust, germs and other organic and inorganic substances. In the surroundings of animal and poultry houses these emissions can lead to damage, nuisance or even impairment of human health. Emissions must be kept as low as possible in order to minimise pollution and nuisance in the environment. Although no emission threshold levels have been stipulated in Germany for livestock houses, minimum distances between houses and for example residential areas or fragile eco-systems are required. These requirements are laid out on one hand in the VDI guidelines and on the other hand in the "Technical Rules for Air Pollution Control", generally referred to by the abbreviated name "TA Luft". The TA Luft of 24 July 2002 contains an instruction on minimum distances for odour emissions as well as on minimum distances for ammonia. The objective of this instruction is to protect delicate plants and eco-systems. Knowledge about emission mass flows from livestock buildings is necessary to apply such rules on distances and to develop low-emission livestock management systems. That is why the Institute of Agricultural Engineering Bornim (ATB) is conducting investigations for a wide range of animal species. This article reports on emission measurements in poultry farming.

Measuring and evaluation methodology

A detailed description of ammonia emission measurements can be found in [1]. This deals with concentration measurements and with the determination of volume flow.

A precise description of the facilities must be reserved for the detailed research report. Only a brief outline is possible here. This is necessary to clarify the connections between the covering building, husbandry, ventilation, livestock species and other parameters and the emission flow rates. The marginal conditions, such as for example climate parameters inside and outside the livestock house or the dry matter content in the faecal matter, are to be documented. One major parameter is the air flow rate through the livestock house. This has a strong influence on the emissions. A simple method of determining the flow rate is to measure the air velocity in the escaping air cross sections. However, manual measurements only supply momentary values. These can only be applied with clearly defined apertures of a manageable number. This method can be improved by fixed installation of velocity sensors (for example impellers - also called measuring fans) and continuous recording of the measurements. Another possibility is to use the tracer gas method. The ATB uses CO_2, SF_6 and Krypton 85 as tracer gas. The methods are described in [1].

While SF_6 and Krypton 85 are introduced into the livestock house in defined quantities, CO_2 is emitted by the livestock themselves. The problem is that the level of CO_2 emitted by the livestock is not known. For instance it is subject to fluctuations throughout the day, depending on the various animal or poultry activities. The concentration measurements (for CO_2, NH_3, CH_4, N_2O, SF_6 and water vapour) are conducted with a multigas monitor. With the aid of a multiplexer, up to 12 measuring points can be connected. When all 12 measuring points are operated, the measuring interval is approx. 16 minutes. The emission mass flow is then determined as a product of the volume flow rate and the concentration. The allocation between the volume flow rate and the concentration in relation to the relevant escaping air apertures is important here.

Poultry houses examined

During the past years ATB has examined a large number of poultry houses, including parent fowl, laying hen and broiler houses and the results have been published [2, 3]. This article reports on measurements in a broiler house (House A) and a laying hen house (House B).

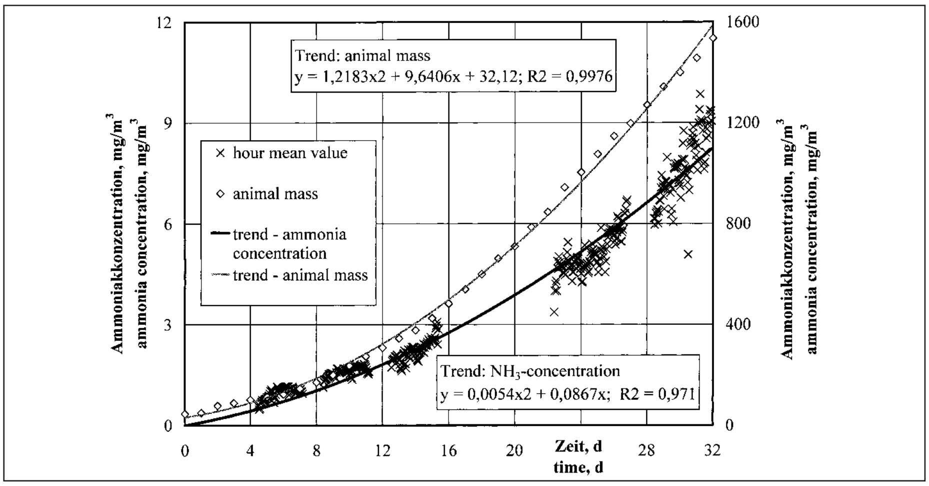

Fig. 1: Course of ammonia concentration and development of live weight during one keeping period in a broiler house (poultry house A / keeping day = 0 => 4. December 2002)

House A:
Number of birds in the house: 44400 / mean live weight throughout the entire keeping period: 0.602 kg per bird / floor management system with straw litter / low-pressure ventilation system - 8 waste air fans arranged along the longitudinal axis of the broiler house convey the escaping air outdoors via the roof - the fresh air flows in via automatically controlled apertures in the side walls.

House B:
Number of birds in the house: 15000 / aviary management system / low-pressure ventilation system - 10 waste air fans arranged along the longitudinal axis of the laying hen house convey the escaping air outdoors via the roof - the fresh air flows in via automatically controlled apertures in the side walls.

Results and appraisal

House A:
During the 32-day fattening period the outdoor temperature fluctuated between -14 °C and 6 °C. The measurements were conducted in winter. The indoor temperature was maintained well at the required levels by the installed climate control and was reduced continuously from 33 °C on the first day of fattening to 21 °C at the end of fattening. The ammonia concentration rose steeply in the course of the management period (*Fig. 1*). This shows the local averaging of all waste air apertures and the ammonia concentration averaged over an hour in each case. The live weight development recorded in the chart shows clearly the influence of the live weight development on the ammonia concentration. In the present case the air flow rate is determined using the tracer gas method (SF_6 as tracer gas). The tracer gas is dosed at the beginning, in the middle and at the end of the management period for several days in each case. Thus the course of the volume flow rate can also be determined well over the management period. Since both the volume flow rate and the concentration rise in the course of the management period, the ammonia emissions increase strongly. Integrating the time plot of the emission flow makes it possible to determine a mean value that can be extrapolated for the whole year. In the present case, taking into account a service period of 14 days, an ammonia emission of 31.8 g/a per bird is obtained. This value is lower than the standard value in Germany (48.6 g/a per bird). The situation is different for methane and nitrous oxide. The nitrous oxide concentration is in the range of the fresh air concentration throughout the entire management period. The methane concentration is between 2 and 3 mg/m^3 at the start, rises a little and swings around values between 4 and 10 mg/m^3. Thus in the course of the management period the rising volume flow rate for methane too leads to an increase in emissions.

House B:
The measurements in the aviary house were conducted in winter 2003 over a period of 6 days when the poultry house was occupied by 14950 hens (1.96 kg per hen) and in summer 2003 over a period of 17 days with 14213 hens (1.875 kg per hen). The air flow rate was determined on the basis of the CO_2-balance and using the tracer gas method (SF_6 as tracer gas). The evaluation in relation to the emission mass flow of ammonia was carried out by analogy with House A. *Figure 2* shows the courses of the volume flow rate, ammonia concentration and ammonia emission by way of example (winter period / CO_2-balance). A daily rhythm with substantial fluctuations in the emission flow is clearly evident. If the ammonia emission from both measuring periods is extrapolated for a year, this results in a value of 131.9 g/a per hen using the SF_6-method and a value of 90.8 g/a per hen on the basis of the CO_2-balance. TA Luft states a calculated value of 91.1 g/a per hen for hens kept in aviaries. Since the CO_2-output of the hens is not known exactly, the value that is favourable under TA Luft contains some uncertainties. In the case under review it was possible here to reduce the emissions substantially by a better-functioning dropping drying facility. The dry matter content (DM content) was between 27 % and 47 % during measurements. On the basis of our own experience a level of at least 65 % DM should be attained for effective emission reduction.

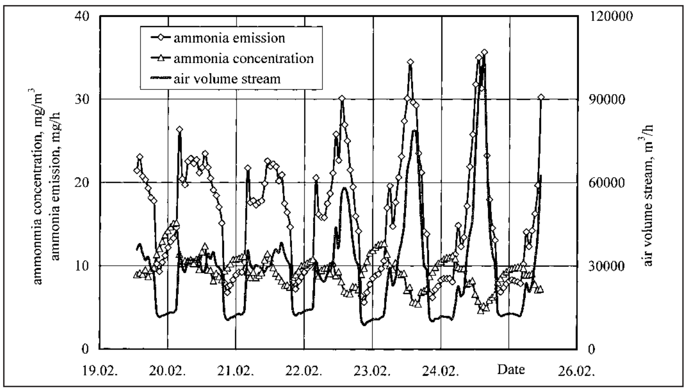

Fig. 2: Course of ammonia concentration, of ammonia emissions and of air volume flow (using SF_6 as tracer gas / poultry house B / February 2003)

The following conclusions can be drawn from the investigations:

- In broiler management emissions rise steeply during the fattening period.
- In these houses emission measurements must therefore be carried out over complete management periods.
- Progress measurements of the volume flow rate are possible with the CO_2-balance if the CO_2 output of the hens is known.
- In aviary management of laying hens low ammonia emission levels can only be achieved if dropping drying leads to DM contents above 65 %.

Literature

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