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Stall Air Quality and Emissions

Measurements in Laying Hen Stalls with Different Housing Systems

The production of reasonably priced eggs requires the application of efficient production methods. However, there is also a demand for animal-friendly housing and environmental compatibility of the housing system. In some cases, these requirements lead to contradictory measures. Animal-friendly housing often causes increased emissions. Thus, the search for solutions which allow emissions to be reduced as far as possible while providing animal-friendly housing must be intensified. Among other prerequisites, this necessitates knowledge about the emission process in different housing systems. Emission measurements in laying hen housing carried out over several years are presented and compared with the results gained by other authors.

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Literature

Literature references can be called up under LT 03317 via internet http://www.landwirtschaftsverlag.com/landtech/local/literatur.htm.

Animal-friendly housing also includes the observance of given stall climate parameters, such as air temperature, humidity, air speed, and noxious gas contents. Such parameters are set by the DIN 18910 standard „Temperature Protection of Closed Stalls" or the relevant animal housing decrees. The stall buildings including the ventilation-technological equipment must be designed and constructed such that these requirements are met. In addition to the emission of dust, germs, and other substances, the ventilation of the stall buildings necessarily leads to the emission of gases and odours. In order to protect the environment from negative effects of gases and odours, so-called „distance regulations" exist in Germany. While odour-related minimum distances between animal housing facilities and residential areas must be kept, the Technical Regulations Concerning Air Pollution govern the necessary distance from sensitive ecosystems on the basis of ammonia emissions.

Practical Measurements

In recent years, the Institute of Agricultural Engineering Bornim has carried out emission measurements in various animal-housing facilities as part of different research projects. These measurements were taken either in cooperation with other research institutions or solely by the institute's staff. Emission measurement was not the exclusive objective. In some cases, immission was studied parallel to emissions. In these facilities, the emission mass flow was determined for only a few hours parallel to the inspections (immission evaluation). Based on such short-term measurements, the assessment of emissions over the course of the year is problematic. For this reason, specific emission measurements during 24 h, 48 h, and one week were taken during different weather periods over the course of a housing period. The measuring methods employed for the determination of air temperature and humidity, gas- and odorant concentrations, and air volume flows are extensively described in reference [1].

In this contribution, some results gained in the three housing systems described below will be presented and evaluated:

- Stall A: 15,000 laying hens / housing on faeces grids (at one level) / storage of the faeces below the grids in a faeces pit over the entire housing period / ventilation by suction using exhaust fans in the ceiling area with evenly distributed fresh air openings in the side walls
- Stall B: 15,000 laying hens / aviary housing at two levels / the entire stall floor (including the space below the aviaries) is designed as a wintergarden / faeces belts with faeces belt ventilation in intervals and emptying of the faeces belts once a week / ventilation variant like in stall A
- Stall C: 47,000 laying hens / cage housing / faeces belts with faeces belt ventilation in intervals and emptying of the faeces belts once a week / ventilation variant like in stall A
- Stall D: 19,500 laying hens / cage housing / faeces belts without faeces belt ventilation; emptying of the faeces belts twice a week / ventilation variant like in stall A
- Stall E: 35,000 laying hens / cage housing in „enriched cages" / faeces belts without faeces belt ventilation; emptying of the faeces belts twice a week / tunnel ventilation (fresh air flows into the stall through eight openings in the east gable and is conveyed longitudinally through the stall and blown out by eight gable fans (array network) in the west gable)

Measurement Results

The author's measurements were carried out in the facilities marked stall A to E (*table 1*). With regard to the stall climate parameters, the results showed that the stall climate parameters required by DIN 18910 „Temperature Protection of Closed Stalls" were generally met. Even without heating, the stall air temperature usually does not fall below the calculated value (14 °C) in the winter. In addition, no problems related to relative stall air humidity occur either in the summer periods or in the winter. The calculated value according to DIN 18910 (80 %) is exceeded only for brief periods. In the examined stalls, the required CO_2 limit of 5.5 g/kg (corresponding to ~ 6,600 mg/m^3) is only briefly exceeded in stall B in the winter with values reaching 7,000 mg/m^3. In the other stalls, a maximum of 4,000 mg/m^3 is reached during winter operation. Ammonia concentration as another important climate parameter is dependent upon ventilation as well as the housing- and demanuring system. While the required limit of 20 ppm (corresponding to ~ 15 mg/m^3) is generally met in the stall variants B to E (these are the systems with a faeces belt), this value is temporally exceeded in the system with a faeces pit (stall A) during the transitional period and in the winter (peak values up to 50 mg/m^3). With regard to stall E, it must be noted that a climate difference between one gable (fresh air side) and the other one (exhaust air side) naturally arises due to the so-called „tunnel ventilation system“. This phenomenon in particular occurs during the cooler season. During this period, the stall temperatures in the fresh-air gable area range approximately 10 K below the temperature values of the exhaust air. Accordingly, the CO_2- and NH_3 concentrations on the fresh air side are approximately 50 % lower than on the exhaust air side. According to the practical experiences of the operator, tunnel ventilation provides good stall-climatic conditions in particular during summer operation. This can certainly be attributed to the wall fans in the gable area conveying large volume flows at relatively low energy consumption.

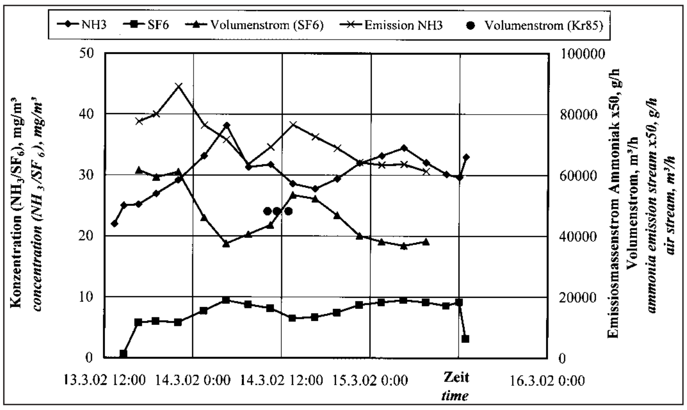

Fig. 1: Mean course of temporal and local concentrations, volume flows and ammonia emissions for house A (winter measuring)

Emissions

The author's emission measurements comprised ammonia and odour. If the measuring periods are relatively short, one can establish a connection between emission and volume flow, which allows the annual value to be estimated. In reference [2], pig stalls are used as an example of an attempted reduction in measurement requirements with the aid of statistical means. However, the indicated errors of 10.9 % for eight measuring days and 6.7 % for twelve measuring days seem to be very optimistic if one considers the comparative studies by [3] for broiler fattening. Complete fattening periods were recorded using measuring technology. *Table 1* of publication [3] shows that the deviations of ammonia emission reach almost 500 %.

The author's own measurements provided relatively high emission values for stall C. This must be attributed to the short measuring period of 20 h under summer conditions. The summer air rates cause relatively high emission values. In the case of stall A, ammonia emissions were measured over 48 hours during one summer-, transitional, and winter period each. *Figure 1* shows concentration, volume flow, and ammonia emission flow during the winter measurement as an example (measurement values averaged over ten measuring points in the ten exhaust air shafts). Annual emission is determined by integration over the entire housing period on the basis of the values of the three measuring periods after allowing for a four-week service period. The value of 470 g of ammonia per year and laying hen corresponds well with the literature values. In stall B, SF_6 dosing was performed over one entire week. Thus, the temporal course of the volume flow during this week was able to be determined and, hence, also the temporal course of ammonia emission. The mean emission during this week served as the basis of a projection for the entire year. The value in table 1 matches well with Hörnig's results. The values of Koerkamp and Van Emous are significantly lower. This can be attributed to the higher dry matter content (DM contents) of the faeces in references [5] and [7]. Stalls D and E were examined parallel during one week. However, the tracer gas technique only allowed for the separate measurement of the volume flows for 24 hours each. The measured ammonia emission values match well with the lower values for cage housing known from the literature.

Due to the short-term measurements, the odour emission flows listed in table 1, which are related to one livestock unit, must be regarded as orientation values.

Housing System	Emission mass flow Ammonia [g/a per animal]	Odour [OU/LU]	Dry matter content in [%]
Stall A (floor)	470	28 – 61	(35,5-51,9)[1] / (63,3-93,1)[2]
Stall B (aviary)	112	33,6 – 62	(36,2-47,1)[3] / (77,0-82,7)[4]
Stall C (cage)	36 – 63	12,3	70[3] – 80[3]
Stall D (cage)	28,9	41,6	-
Stall E (enriched cage)	19,0	40,2	-
Hörnig et al. [4]			
Cage battery	16,6 – 18,3	-	-
Aviary housing	104,2 – 136	-	-
Groot Koerkamp [5]			
Compost system	386	-	-
Cage battery	35	-	75
Aviary housing	17,5 – 25	-	85 – 90
Janzen et al. [6]			
System like stall A	464	-	-
Van Emous et al. [7]			
Aviary „Natura Nova“	24,8	-	64,8[3] / 84,9[4]
Aviary „Comfort/Compact“	41,4	-	68,8[3] / 81,1[4]

1) faeces pit – well dried spots; 2) faeces pit – poorly dried spots; 3) faeces; 4) litter

Table 1: Comparing measured emission mass flow data with bibliographical references

Conclusions

The author's measurement results, which correspond with the literature values, show the significant influence of the housing- and demanuring system on emissions. Not least due to insufficient faeces drying, the storage of faeces in the stall leads to considerably larger ammonia emissions than in systems with faeces belts. In order to reduce ammonia emissions, the DM content of chicken faeces should exceed 65 %. Tendentially, this also applies to odour. Further fundamental studies on the emission process are necessary. In order to minimize the trial-technological requirements, measurements must be combined with the modelling of partial areas, which include real physical and chemical processes.