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Emissions from broiler fattening

Results of long-term monitoring

In the national emission inventory, broiler fattening is relatively unimportant because substance conversion in this branch of production is relatively insignificant. Nonetheless, emissions from broiler fattening stalls cause problems in permit procedures according to the Federal Immission Protection Act (neighbourhood conflicts, undesirable nitrogen deposits), which lead to a demand for current emission data by broiler fatteners, counsellors and authorities. Therefore, the authors have carried out measurements in up to three stalls of a broiler fattening farm for three years. Based on these measurements, the emission data presented here were calculated.

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Literature

Literature references can be called up under LT03123 via internet http://www.landwirtschaftsverlag.com/landtech/local/literatur.htm.

Larger broiler fattening farms are often situated near forests or other biotopes worth protecting. For them to remain in operation or to expand their capacities for economic reasons, environmental impact analyses are required, which must take operational peculiarities and locational conditions into account. The absolute quantity of ammonia emissions from broiler stalls given for Germany, for example, amounts to 6 kt NH_3. This corresponds to only 1.2% of the total ammonia emission from animal husbandry in Germany [1]. This shows that the emissions from this area of animal husbandry are less important for national emission reduction strategies and mainly constitute a locational problem.

Variabilities in the emission process in a production unit were registered during different fattening periods. The individual measuring periods differed in length and were mainly concentrated at the end of the fattening period having the largest emission mass flows. For ammonia, for example, the emission data from littered broiler fattening found in the literature ranged between approximately 20 and 250 g NH_3 per animal place and year [2 to 8].

If the emissions are extrapolated for one year with seven husbandry periods, the annual mean value amounts to about 50 g NH_3 per animal place and year. The emission peaks at the end of the fattening period exert a significant influence on the annual mean value.

Housing Conditions

The housing conditions on the farm chosen for the studies fulfill the minimum requirements for broiler housing [10] and even exceed them in many points. While the trials were carried out, a maximum of 22,500 chicks were stalled up in one stall. The stalls feature forced side-wall ventilation with the intake- and exhaust sides of neighbouring stalls being opposed to each other. The measurements were carried out in stalls 6, 7 or 8 out of a total of nine stalls so that each of the „experimental stalls" had two neighbouring stalls and, hence, featured comparable flow conditions. For supplemental heating, gas-blower direct heating systems are used. Climate control, feeding and process documentation are controlled by computers using a management program for the entire farm. During the period under consideration, the fattening duration was 35 to 42 days. The animals are kept on plane wood chips as litter. After each fattening period, the stall is demanured and immediately afterwards the manure is carted away from the farm area.

Measuring methods and measuring points

With the aid of long-term data loggers for temperature and relative humidity, the outdoor- and stall values were measured and stored. The multi-gas monitor 1302 and the multiplexer 1309 from Brüel&Kjmr were used to measure the gas concentrations of ammonia, carbon dioxide, methane, and nitrous oxide. Each analyzed stall had a measuring point for gas analysis. Outdoor air concentration was measured in the air intake area between stalls 6 and 7. In order to reduce entrainment effects between the different measuring points, the measurements were repeated several times at each measuring point. The measurements took place continuously over several (up to 34) days. The relatively small number of measuring points allows for a rather high temporal resolution of the dynamics of the gas concentration values at the individual measuring points.

For the determination of odorant concentration, samples were taken at the exhaust fans. These samples were analyzed at the ATB by a team of experienced test persons using the olfactometer TO 7.

Determination of the emission mass flows

Due to the practical conditions (ventilation system, duration of the trials), the carbon dioxide balance method according to the 1992 edition of the DIN 18910 standard had to be used to calculate the ventilation mass flows. Carbon dioxide production by both the animals and the direct heating systems was ta-

day of fattening	methane	daily emission nitrous oxide mg/animal • d	ammonia	"standard value"[1] mg/animal • d	odour LU/s
20	21 - 95	3,2 - 8,6	46 - 209	15	
21	20	3,1 - 9,2	6 - 206	18	
22	9 - 24	4,7 - 11,1	12 - 190	24	
23	8 - 68	4,3 - 9,5	85 - 222	34	
24	6 - 52	3,2 - 12,8	75 - 244	52	
25	13 - 73	1,9 - 11,4	73 - 273	71	
26	9 - 60	2,0 - 11,3	78 - 300	98	
27	16 - 69	2,9 - 10,1	104 - 312	126	
28	20 - 80	2,6 - 9,7	59 - 298	160	
29	15 - 151	2,3 - 12,1	72 - 317	196	
30	24 - 134	2,8 - 13,2	67 - 386	234	
31	12 - 178	2,1 - 12,9	74 - 433	276	
32	11 - 139	2,8 - 14,2	73 - 437	319	49 - 123
33	6 - 188	2,7 - 15,7	98 - 445	366	231 - 298
34	8 - 193	3,5 - 9,4	103 - 444	414	237 - 274
35	31 - 390	3,5 - 15,8	110 - 505	465	116 - 424
36	116 - 406	3,7 - 16,1	107 - 358	516	50 - 148
37	336	3,1 - 15,3	91 - 204	569	260 - 362
38	374	4,0 - 16,3	91 - 227	623	
39	210 - 410	4,2 - 15,9	127 - 247	677	
40		2,2	208	732	
41				788	
42				843	

1) according to [9]

Table 1: Emission data for selected days of fattening period

ken into account. The current daily number of animals and their mean live weight were available for the calculation of the broilers' carbon dioxide production. In order to be able to use the higher live weights not considered in the DIN standard in the calculation, an exponential function was established (equation 1) with n standing for the number of animals and LM for the mean live mass of the individual animal in kg.

$$\sum \dot{K}_{ST} = n \cdot 3{,}0153 \cdot LM^{0{,}7676} \quad (1)$$

If air density is taken into account (table 14 of DIN 18910), the volume flow can be calculated, which provides the emission mass flow when muliplied by the difference of the gas concentration values. Even though the emission mass flow is given in g/h, these are mean values for the individual fattening day because only mean daily values can be employed to measure carbon dioxide emission by the animals.

The carbon dioxide masses from the combustion air were determined based on the running time of the heaters.

Gaseous emissions

Table 1 shows the ranges of the gases methane, nitrous oxide, and ammonia on the individual fattening days. For comparison, the daily values of the idealized emission curve shown in reference [9] are given. The term „standard" results from the annual mean value of 50 g NH_3 per fattening place and year commonly used for environmental impact analyses.

In the described housing system, emissions of methane, nitrous oxide and ammonia are produced over the entire fattening period. While nitrous oxide emissions approximately remain within a constant fluctuation range during the evaluation period, methane exhibits a tendency towards increasing values towards the end of the fattening period. Due to the high variation coefficients, statistical trend analyses of these two gases only lead to functions with very low determinateness so that their publication is virtually irrelevant.

A comparison of the calculated ammonia emission data with the „standard" shows that in the individual measuring periods the values may fall substantially below the „standard". Single-day maxima, however, may also exceed the idealized curve. Especially as of the 35th fattening day, the standard seems to be overrated. However, this result must be relativized in so far as no comparable sets of data for the entire fattening period are available since after fattening periods characterized by high emission values the animals were stalled out at the latest on the 36th day. In a comparison with [9], the statistical trend analysis of all ammonia values upon which *table 1* is based led to a flatter course at medium determinateness.

Odour emissions

Separate measurement values are only available for days 32 to 37 (*table 1*). In the first three weeks of the fattening period, however, virtually no specific odours can be perceived in the environment of the stalls.

The odour emissions were calculated based on anemometric short-term measurements at the exhaust fan during sampling.

As compared with other publications, 200 to 400 odour units (OU) per second at the end of the fattening period seem to be low values.

Summarizing discussion

Emission data from broiler fattening not only exhibit high variability from stall to stall, but also between the individual fattening periods even if the stalls are managed uniformly. The present trials were not primarily designed for the determination of the reasons for the variations.

The sporadic occurrence of methane- and nitrous oxide emissions in broiler fattening stated in the literature is confirmed by the authors' measurements. Within the wide range of the ammonia emissions given in the literature, the presented values can be classified as rather low. The trials carried out by the authors also showed a tendency towards emissions in earlier fattening periods being higher than in later ones. This is considered a result of systematic management. In addition to demand-oriented feeding strategies, the interest of the farm management and the caretakers in particular focuses on the litter-/manure properties. Under the described production conditions, it seems realistic that the ammonia emissions can be kept below the values assumed in permit procedures.

Future prospects

The further cause-related measurement of emissions from broiler fattening is necessary in order to offer licensing authorities and fatteners reliable data material. Methodical uncertainties in the realization of the presented trials and data evaluation will be reduced in future studies by the authors. In a specially equipped stall, the volume flow will be measured by measuring ventilators in the exhaust shafts. In addition, the running periods of heaters will be directly registered by the control system, and a larger number of measuring points and sensors will limit the randomness of the measurement values further. As a supplement to the continuous recordings of the measuring ventilators, short-term volume flow measurements with the aid of tracer methods will be carried out. Especially in comparative studies, the combination of emission measurements in practice and in the laboratory with faeces- and manure analyses has proven itself in order to assess the logic of the partial results. Nutrient balances at the stall level will be another means of cause-related emission analyses.