Hahne, Jochen

Dynamic and range of emissions from poultry keeping

Relevant trace gas emissions from two chicken houses in small group housing were measured from 2009 to 2012. The emissions were varying widely and, in case of ammonia, depending on the dung removal rates. Between those the ammonia emission increased daily up to 120 %. The trace gas and particulate matter emissions as well could be correlated with the volume flow at a constant stable management. While methane, nitrous oxide and hydrogen sulfphide emissions were low with 9 ± 7, 7 ± 2 and 4 ± 1 g per head and year at specific air flow rates of 8.2 ± 1.4 m³ per head and hour, ammonia emission for this housing system was in a common range with 148 ± 29 g per head and year. The carbon dioxide emission exceeded with 46 kg per head and year the ammonia emission by a factor of 311. Specific odor emissions varied with 15–84 odor units (OU) per second (s) and livestock unit (LU). In mean the odor emission was 43 OU s^{-1} LU^{-1}.

Keywords
Poultry keeping, ammonia, trace gases, emissions, emission factors

Abstract
Landtechnik 68(5), 2013, pp. 306–309, 4 figures, 2 tables, 3 references

Relevant trace gas emissions from two chicken houses in small group housing were measured over a period from 2009 to 2012. The emissions were varying widely and, in case of ammonia, depending on the dung removal rates. Between those the ammonia emission increased daily up to 120 %. The trace gas and particulate matter emissions as well could be correlated with the volume flow at a constant stable management. While methane, nitrous oxide and hydrogen sulfphide emissions were low with 9 ± 7, 7 ± 2 and 4 ± 1 g per head and year at specific air flow rates of 8.2 ± 1.4 m³ per head and hour, ammonia emission for this housing system was in a common range with 148 ± 29 g per head and year. The carbon dioxide emission exceeded with 46 kg per head and year the ammonia emission by a factor of 311. Specific odor emissions varied with 15– 84 odor units (OU) per second (s) and livestock unit (LU). In mean the odor emission was 43 OU s^{-1} LU^{-1}.

Material and methods

Investigations to record emissions from two chicken stables were conducted in the period between 2009 and 2012. A direct attribution to a defined housing system as described in the National Evaluation Framework (Nationaler Bewertungsrahmen) [1] and the VDI guideline (VDI-Richtlinie) [2] is not possible conditioned by the experimental set-up of the stables.

The housing system complies mostly with the small group keeping (system H/LH0412). The closed and thermally insulated stables with an animal stock between 450 and 600 heads, which changed over the years, were equipped with forced ventilation.

The manure removal was realized by belts, which could be ventilated if necessary. For emission recording online measuring systems with automatic calibration were predominantly used (**Table 1**). All trace gas concentration values were corrected to eliminate the ambient air influence. The data represent insofar net emission values.

The olfactometry, a method to determine the odour concentration, was performed by an accredited laboratory (Braunschweiger Umwelt-Biotechnologie GmbH).

Results

The exhaust air temperatures of the tested stable were 21.2 ± 1.8 °C in 2011 (n = 2885, 2 h means). Conditioned by high ambient air temperatures values of 36.3 °C were measured in maximum, but only for a short time (**Figure 1**). In the same period the relative humidity in the exhaust air was 58.5 ± 7.9 % and 82.4 % in maximum.

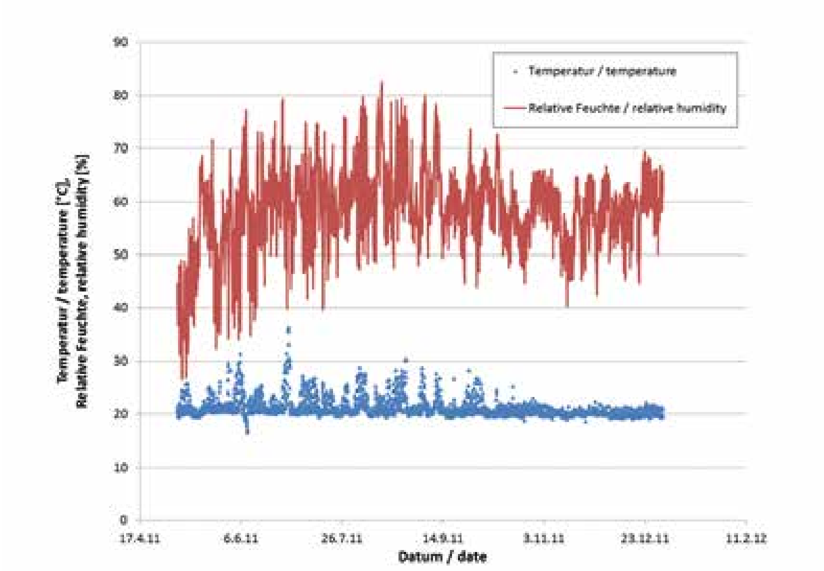
The air flow rates were subject to considerable daily and annual fluctuations with values of 4903 ± 4378 m³/h (n = 2850, 2 h means) (**Figure 2**). Dynamic changes of the air flow rate between day and night occured particularly in the summer time. The mean air flow rate was 40 % of the maximum which was dimensioned to be 12,300 m³/h. Conditioned by decreasing

Table 1

Measurement categories and analyzers for exhaust air determination

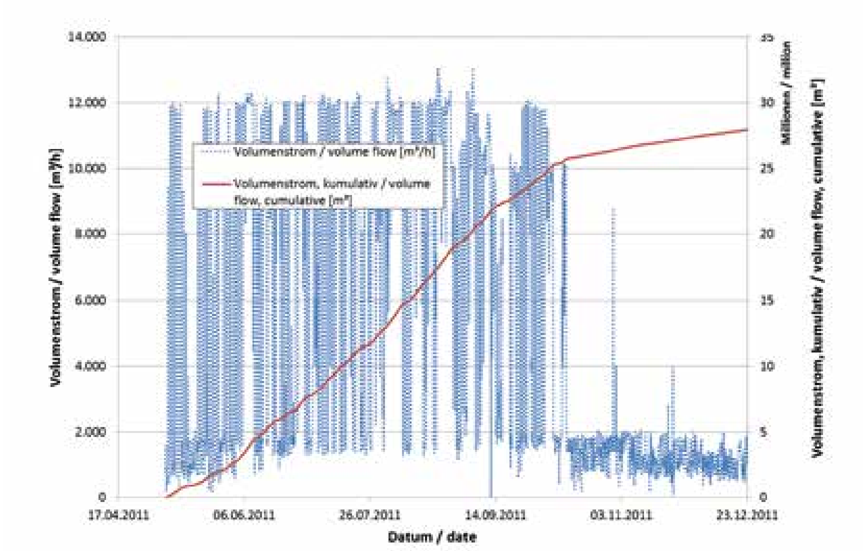
Parameter/*Parameter*	**Gerät/*Measurement equipment***
Ammoniak/*Ammonia*	FT-IR Cx 4000, Ansyco, Karlsruhe
Distickstoffoxid/*Nitrous oxide*	FT-IR Cx 4000, Ansyco, Karlsruhe
Kohlenstoffdioxid/*Carbon dioxide*	FT-IR Cx 4000, Ansyco, Karlsruhe
Schwefelwasserstoff/*Hydrogen sulphide*	Limas 11 AO 2020, ABB, Frankfurt
Volumenstrom/*Volume flow*	Thies Ultrasonic Anemometer, Göttingen
Temperatur/*Temperature*	Vaisala HUMICAP HMT 330, Helsinki
Gesamtstaub/*Total dust*	Sick FW 100, Reute
Partikelgröße/*Particle size*	Grimm 1.109, Ainring
Relative Feuchte/*Relative humidity*	Vaisala HUMICAP HMT 330, Helsinki

Fig. 1



Example of temperature and humidity course in the exhaust air of the chicken house

Fig. 2



Example for daily and annual volume flow fluctuations in a chicken house and the development of total volume flow as well ambient air temperatures in October the air flow rate also decreased considerably.

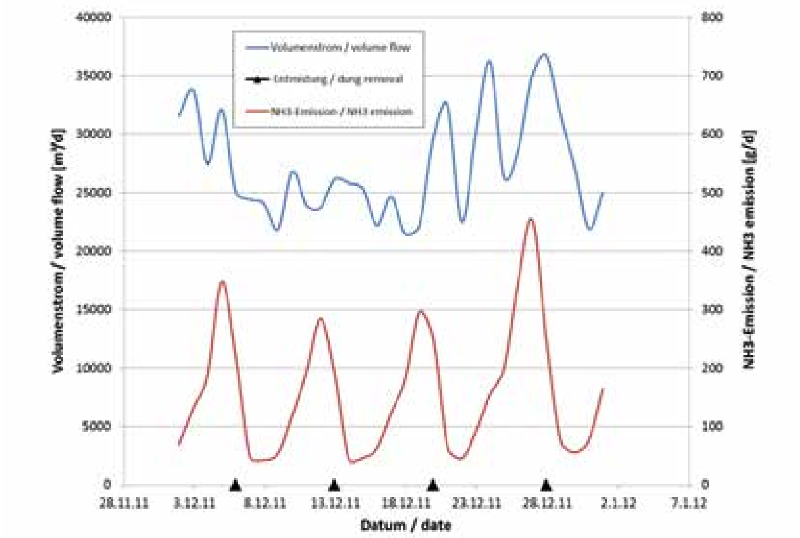
The daily ammonia emission did not show a relevant correlation with the air flow rate (**Figure 3**), but in fact, it strictly depends on the time lag to the last dung removal. This correlation has been already reported [3]. Therefore the shortening of dung removal intervals represents an essential action to reduce ammonia emissions as also described in the National Evaluation Framework [1].

With an animal stock of 454 heads the daily ammonia emissions varied between 42 und 453 g/d (mean = 157 g/d) in December 2011. In June the emissions were between 33 and 909 g/d (mean = 458 g/d) with a comparable animal stock. In this respect the ammonia emissions in June were threefold higher than in December. The air throughput with 5,133,400 m³ in June was sixfold in comparison to December.

At a fixed and constant stable management the emissions of particulate matter, ammonia and carbon dioxide could be well correlated with the air flow rate. In the time period between 5th May and 31th December the air throughput was 28, 205, 546 m³. During this time 62, 726 g NH_3, 18579 g particulate matter and 16,401.5 kg CO_2 were released (**Figure 4**).

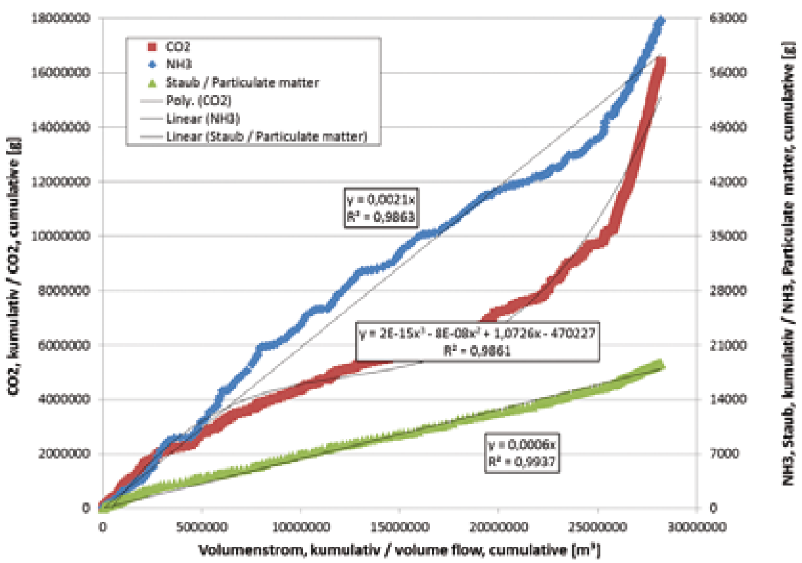
The CO_2 emissions particularly resulted from the animal respiration and were associated only indirectly with the air flow. Because of the fact that the particulate measuring point was not located in the stable exhaust but in the entrance of the test

Fig. 3



Course of dung removal, volume flow and ammonia emission in the tested chicken house

Fig. 4



Correlation between volume flow and emission of NH_3, CO_2 and particulate matter at a constant stable management

Table 2

Specific trace gas emission of the tested chicken houses

Parameter/*Parameter*	**Einheit/*Unit***	**Minimum**	**Maximum**	**Mittel/*Mean***	**SA/*SD*[1)]**
Spez. Luftvolumenstrom *Specific air flow rate*	m^3/(TP h) *m^3/(AP h)*	6.1	10	8.2	1.4
H_2S	g/(TP a) *g/(AP a)*	3.5	4.3	4	1
CH_4	g/(TP a) *g/(AP a)*	1.8	21.9	9	7
CO_2	kg/(TP a) *kg/(AP a)*	38	55	46	7
N_2O	g/(TP a) *g/(AP a)*	5.3	10	7	2
NH_3	g/(TP a) *g/(AP a)*	121	201	148	29

1) SA: Standardabweichung/*SD: standard deviation.*
2) TP: Tierplatz/*AP: animal place.*

facility after an one quarter pipe the coarse dust fraction was probably not captured. Therefore the particulate matter values cannot be assessed as emission data.

The air flow rates and the emissions from both chicken stables were partially measured over several years. Because of a comparable operating method the values of both stables were summarized and converted to specific and year-round emission data (**Table 2**).

As expected the emissions of N_2O, H_2S and CH_4 from the chicken keeping were low with 7 ± 2, 4 ± 1 and 9 ± 7 g per animal place and year (g/(AP a)), respectively. CH_4 emissions decreased with the total air throughput. The latter was relatively high with 8.2 ± 1 m^3/(AP h) and complies rather with a summer ventilation rate. Ammonia emissions with 148 ± 29 g/(AP a) were comparable with emission factors which have been reported for small group housing systems operating with a weekly dung removal by non-ventilated dung belts [2].

Odor measurements by the Braunschweiger Umwelt-Biotechnologie GmbH (n = 10) showed mean emissions of 43 ± 22 odor units per livestock unit and second (OU s^{-1} LU^{-1}), but with a fluctuation range between 15 and 84 OU s^{-1} LU^{-1}. These values are slightly higher than the 30 OU s^{-1} LU^{-1} which were reported in [2].

Conclusions

A constant stable management assumed the emission of trace gases (NH_3, CO_2, and N_2O) and particulate matter from chicken keeping can be reduced by a decrease of the total air throughput. For the very low CH_4 emissions only a moderate increase has to be expected in this case. A conditioning of the incoming air or a concerted heat release is required to achieve an emission reduction via decrease of the total air throughput. The shortening of dung removal intervals is decisive for a reduction of ammonia emissions.

If exhaust air treatment systems will be used for emission reduction from chicken stables, it should be constructed in a modular manner and equipped with a high flexibility to secure an efficient emission reduction under rapid changing operating conditions.

References

[1] KTBL (2006): Nationaler Bewertungsrahmen. KTBL-Schrift 446, Darmstadt
[2] VDI-Richtlinie 3894 Blatt 1(2011): Emissionen und Immissionen aus Tierhaltungsanlagen. Ausgabe 2011-09, Berlin, Beuth Verlag
[3] Hahne, J. (2010): Mehrstufige Abluftreinigung für die Geflügelhaltung. Landtechnik 65(5), S. 334–337

Author

Dr. Jochen Hahne is a scientific associate at the Thünen-Institute of Agricultural Technology, Bundesallee 50, D-38116 Brunswick, Germany, e-mail: jochen.hahne@ti.bund.de