Krause, Karl-Heinz and Linke, Stefan

Examine the ventilation of aviary husbandries with regard to environmental compatibility

Manufacturers of aviary stables generally disappoint purchasing farmers when it comes to providing documentation on plant-specific emissions. So it can happen that the same type of stable in a licensing procedure is considered to be sufficient to the duties of immission protection and on the other hand it fails. Moreover there are many different types of stables on the market. E.g. some aviary stables are processed by solid manure. Aviary frames are positioned on the littered areas. In dung pits the solid manure is gathered which is transported by belts. In other cases the dung pit is avoided and there are ventilated belts of feces in the different floors of the frames. In the literature (e. g. VDI 3894 Blatt 1 E) the emission factors of ammonia reach from 0.06 to 0.32 kg/(year • animal place). There is a lack of remarks on the construction of the ventilation. In the following the possibility is shown to investigate an exemplified aviary stable with regard to altered constellation of ventilation by simulation techniques.

Keywords
Laying hen husbandary, aviary husbandry, emission reduction, environmental protection, animal protection, energy saving, filter technology, simulation

Abstract
Landtechnik 65 (2010), no. 5, pp. 329-333, 6 figures, 2 references

If a farmer wants to or must convert his chicken-keeping from cage-keeping to aviary stables, he is confronted with an approval process. The change of the keeping systems is often linked to the building of a new stable or changes in an existing stable. Since the aviary structures must be of a certain height (**figure 1**) they sometimes don't fit into older buildings. Although the animal species is not changed in the switch in the form of chicken-keeping, governmental agencies often see the building changes as a change in use. They therefore require proof of the environmental effectiveness of the changed or new animal husbandry equipment. Then the farmer is obligated to provide evidence. He must prove that his animal plant meets the legal requirements both in terms of emissions and environmental compatibility [1; 2]. Here emissions factors, for example for ammonia, odours and dust, are of great relevance. But stable equippers generally provide no information on this topic. However, it is possible use simulations to assess the emissions levels of aviary keeping to check their approvability. In the following an example will be described of how the prognostic flow model STAR CCM+ can calculate the aviary stable air input and output flows as well as the emission factors.

Differing air flows

It would make sense to study a planned commercial stable to examine its acceptability before putting it on the market. This, possible in other branches, can also be done in animal production. In this manner, for example, the design of an auto body

Fig. 1

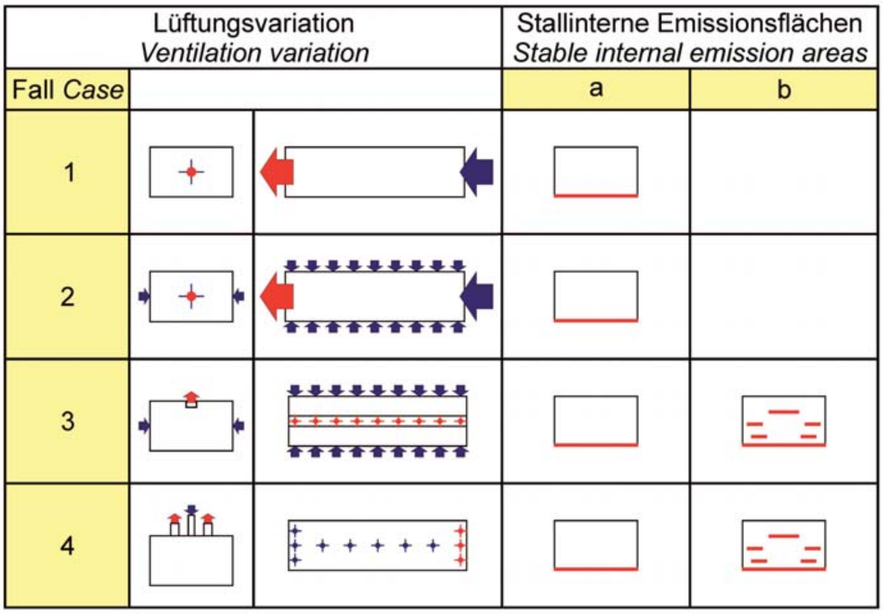
Aviary husbandry with ventilated belts of feces in different heights of floors

is subject to tests on the scientifically technical possibilities through a simulation. In this manner, “proven” experience treasures can be moved forward with modern planning methods. Of concern in aviary housing, as in animal husbandry on the whole, is the impact of the air flow on the climate in the stable and on the emission behaviour of the facility. Since the manufacturers generally remain silent on the topic of the emissions factors of their products, farmers who want to have their facilities approved must draw upon the so-called opening clause within the technical guidelines for air pollution control. These provide a possibility to include own data for emissions factors with an appropriate scientific basis.

If no documentation is available on recommendations for a classification of the distribution behaviour of a certain stable facility, emissions factors are sometimes established by consensus of the participants. But this supposed pragmatism offers a poor basis if one wishes to push through further developments in stable construction.

The correct professional approach is to use distribution calculations to prove that the emission load of a type of animal husbandry is tolerable. This challenge cannot be met with reduced basic assumptions because, particularly in aviary stable construction, there are numerous types of stables and thus different emission factors. Thus, for example, one can often find roofed outdoor runs that are added to the long side of the stable facilities. The question is how to „dock“ this construction onto the existing stable: should stable air be sucked out into the roo-

Fig. 2



Investigation of the same stable room (length 43.2, width 11.2 and height 3.55 m) at variable boundary conditions.
Case 1a: air inlet and air outlet at the gables
Case 2a: corresponding to 1a) with additional suction of fresh air through the inlet openings in the sidewalls (point sources)
Case 3a: suction away of stable air through line sinks in the ridge and suction of fresh air through line sources in the sidewalls
Case 4a: suction away of stable air through point sinks through the ridge and suction in of fresh air through point sources in the ceiling.
The constellations 3b and 4b refer to those in the cases 3a and 4a, but with the installation of volary frames

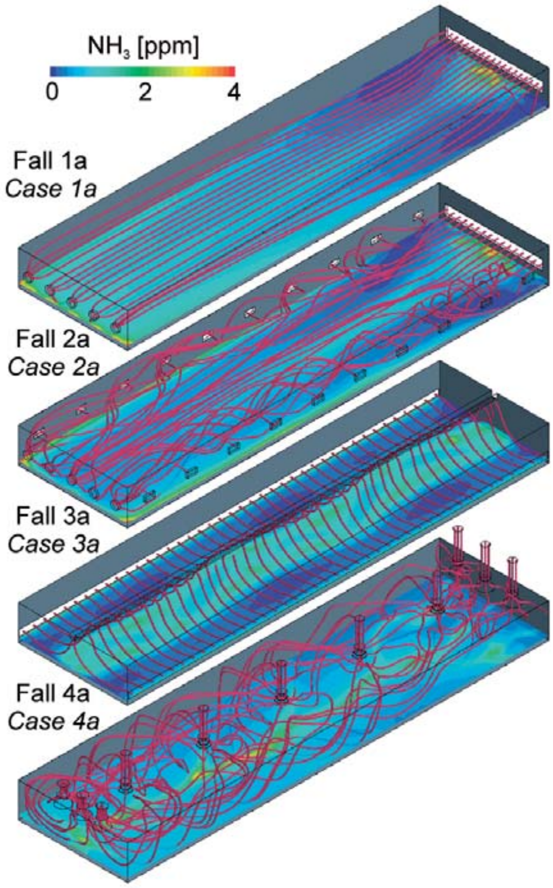
fed outdoor runs and then be blown outside? Or is it better to suck fresh air through the roofed outdoor runs into the aviary stable?

In order to make clear how serious the permanent effects of ventilation are in the simulation described here, one and the same stable area is studied in **figure 2** with different ventilation systems and stable constructions. In order to make the inflow and outflow areas accessible for a systematic description, the removal of stable air from the stable room is assigned a sink impact, the inflow a source impact. The sink serves as the active air portion for the installed ventilator. Source and sink show different behaviour concerning the depth of their impact in the stable. A deep impact is caused by free stream behaviour with a strong turbulent input. Furthermore, sources and sinks can be affected by a design factor in that one models them, in a simplifying way, as a point, line or area. Due to the voluminous behaviour, this design affects a source area of the ventilation system more than a sink area. In the four introductory examples, the total ground plate serves as an internal stable emission area with a concentration of 20 ppm of ammonia.

Interpretations

In „tunnel ventilation", (Case 1 a **in figure 3**) the air is drawn into the stable via air supply hatches (small area sources on the left) into the stable rooms. If additional air supply hatches on the side walls are opened (Case 2 a) then air masses penetrate into this area due to the low atmospheric pressure in the stable and tie up the main flow in a bundle. The concentration of pollutant gases reduces toward the centre of the stable. One can significantly shorten the suction paths between the inflow and outflow air by using a ceiling exhaust slot for suction (line sink) and allowing the fresh air to flow in through vents the side walls (linear sources (Case 3a). In this manner one obtains a very even speed field, which is of significance in the control of the air flow. The deviations in the individual cross cuts are not as serious as in the examples of Cases 2a and 4a. In Case 4a, the inflow and outflow openings are found in the form of point sources and sinks in the ceiling. The flow plunges from top to bottom in a free stream style and exits from under the gables (left). Between the inflow and outflow openings, a so-called stable wind is created which also carries the foreign materials from the stable internal emission areas with it and carries them to the exhaust openings. Of interest there is the uptake of the pollutants at the boundary level. The material transfer is caused by a partial pressure drop that is firstly dependent on the speed of the air flow and secondly on the temperature. This process will, in the case of an aviary, be more complicated if, namely as in **figure 4**, structures with walkways are built on multiple levels. Below the walkways, the so-called manure belts, over which the air streams are blown, can be found. These are blown with excess pressure from a small, central canal and dry the manure and urine mixture (faeces) to a crumbly mass. Local speed changes

Fig. 3



The ammonia concentration distribution at 0.5 m is shown for the first four cases in the free poultry stable areas. The concentration at the bottom is in all cases 20 ppm.

Case 1a: Fresh air input on the left side, stable air output on the right side. The concentration decreases from local input of fresh air to the local output of stable air

Case 2a: The concentration is lower at the bottom than in case 1a) and distributed more evenly

Case 3a: The distribution of concentration is nearly the same in all cross-sections, at the boundary low, increasing to the middle of the stable

Case 4a: The tendency of concentration is nearly the same as in case 3a, but with a very diffuse air distribution because of the point sources and sinks in the ceiling can occur through the installation of structures or obstacles (**figure 5**). In the ground area these have proven to raise the concentrations less in the ordering of line sources and sinks in Case 3b, than in Case 4b with the ordering of point sources and sinks in the ceiling areas.

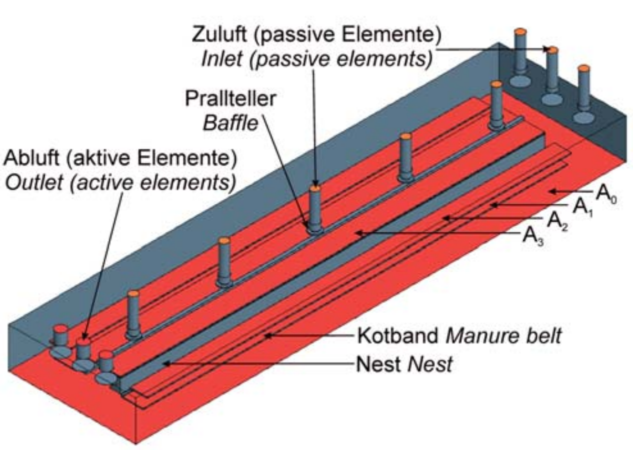
Conclusions

The study results make it evident, that the construction form shown in Case 3b should be realized in aviary stables like those treated here (**figure 6**). Here the fewest emissions are to be expected to be carried outwards. The manure belt drying leads to a reduction of the mean concentration above the entire emission area, despite the larger area of emission. The local concentration on the area A0 on the stable floor increases strongly due to the high entry speed. This holds true to the same extent for both the systems 3b and 4b.

The emission factor results from the sum of the product of concentration and flow volume over all of the exit areas (linked to the DIN 18910 in terms of animal physiology), multiplied with the portion of the emergence frequency of the set volume flows and divided by the number of animals. In the given case, the simulation was repeated for further typical ventilation settings in relation to the flow volume, and the emission factor was determined from that, as previously described. In Case 3b this is 0.47 × 2.2 mg/(year × Ap) = 0.009 kg/(year × Ap) – Ap denoting „Animal place“ – , in Case 4b to 0.031 kg/(year × Ap). The factor 0.47 represents the averaged frequency of occurrence of the various flow volumes. **Figure 6** also gives the construction information, that per animal place, an emissions area of 1,000 cm² can be assumed.

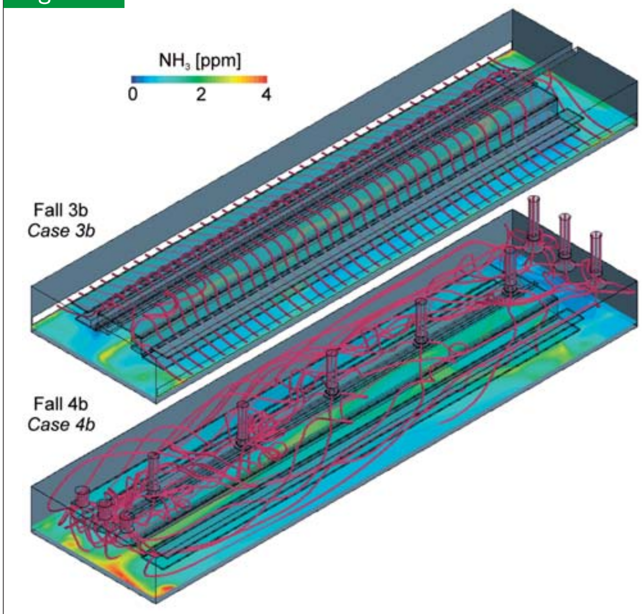
The frequently cited argument that the farmer presents the largest uncertainty factor in calculating the emission factors through his use of the facilities simply means a variation of the boundary conditions for the simulation, for example should he cause an increase in concentration above the internal stable emission areas through bad litter. In comparison to the causal-analytically supported simulations here, the emission factors more or less “found” by consensus are less reliable. Time will show which variant proves to be better for the farmers in the long term. The true test will then come if a building permit is challenged in court and its correctness is called into question there.

Fig. 4



Aviary frame with ventilated manure belts at different floor heights: A1, A2 and A3. The bottom layer is A0

Fig. 5



The air movement in the centre of the stable is diminished by the installation of aviary frames in comparison with the Cases 3a and 4a. The internal stable emissions rise in Case 4b due to the increase in turbulence.

Literature

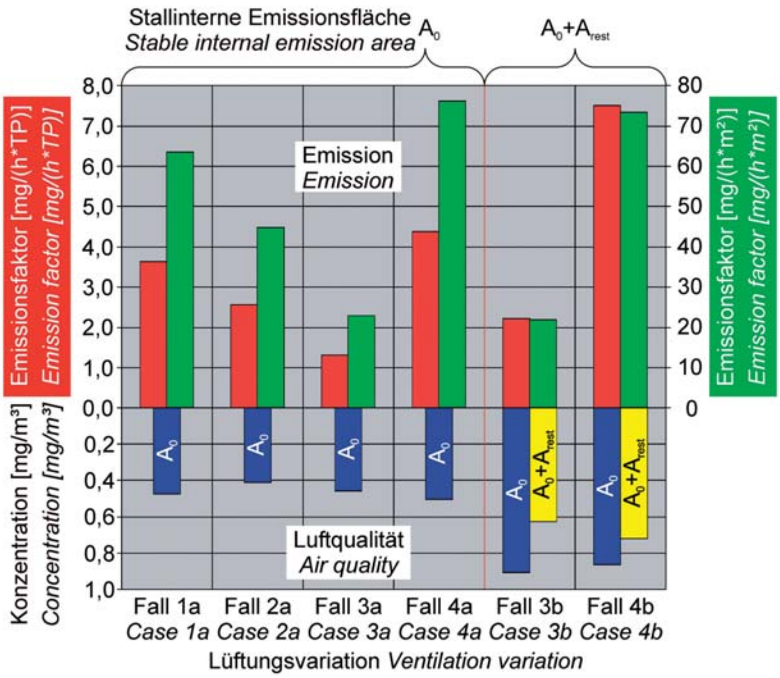
[1] DIN 18910-1 (2004): Wärmeschutz geschlossener Ställe. Wärmedämmung und Lüftung, Teil 1: Planungs- und Berechnungsgrundlagen für geschlossene zwangsbelüftete Ställe. Hg. DIN Deutsches Institut für Normung e.V.

[2] Krause, K.; Linke, S. (2009): How to describe animal welfare in stable design? Proceedings of the XIV ISAH Congress 2009, July 19.–23.2009: Sustainable animal husbandary

Authors

Dr.-Ing. Karl-Heinz Krause ist wissenschaftlicher und **Stefan Linke** technischer Mitarbeiter am Institut für Agrartechnologie und Biosystemtechnik des Johann Heinrich von Thünen-Instituts (vTI), Bundesallee 50, 38116 Braunschweig, E-Mail: karlheinz.krause@vti.bund.de, stefan.linke@vti.bund.de

Fig. 6



In dependency on the arrangements (1a to 4a without aviary frames and 3b to 4b with aviary frames) the emission factors are shown in the upper part with regard to the animal (red) resp. with regard to the emission area (green) and in the part below the mean concentration 0.2 m above the internal emission areas of the stable. The stables with lowest emissions are those ones with line sources and sinks