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Simulation model for ammonia emissions

Comparison with measurements in naturally ventilated dairy cattle housing

With a mechanistic emission model, ammonia emission from livestock buildings can be estimated. In the model, the ammonia released from the slatted floor and from the slurry canal was calculated separately. A comparison with emission measurements in a naturally-ventilated dairy cattle house showed a good agreement. The average intensity of the ammonia emission was mainly determined by the pH value, the dynamic was influenced by the temperature and a varying air exchange from the slurry canal through the slats.

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Keywords

Ammonia emissions, emission calculation, simulation model

The measurement of the ammonia emission from livestock buildings is associated with a high technical expense. For more rapid and simple estimation a model was developed by [1] which calculates the ammonia emissions from a cubicle house for dairy cows through mathematical formulation of the physical-chemical formation and release procedures of ammonia.

The simulation model

The model [1] comprises separate modules for ammonia production from the floor and from the storage in the slurry canal. The floor module recorded the urine deposition on the slatted floor, the enzymic degeneration of the urea, the dissociation balance of ammonia and its convective release from every urine pool that remains on the slatted floor after every urine deposition. The storage model contained, along with the dissociation and convective release of ammonia from the total slurry surface, the production amount of excreta and urine. In a further development of the model, the air exchange through the slatted floor is also considered in association with the temperature difference between intake and interior air [2]. Through this was calculated in the storage module the ammonia emission from the storage through a total balance for ammonia with the balance terms ammonia production and removal through air exchange over the slatted floor.

Comparison with measurement results

For validating the models and for checking the usability in naturally ventilated buildings, the simulation results were compared with measurement results from a naturally ventilated dairy cattle house. The cow house and the examples of the emission results have been already presented [3,4].

General input parameters for the model calculation were taken from [1]. The stall-specific input parameters are collated in table 1. Calculated as dynamic input value were the 20 minute average values of the measured building interior temperature, which influenced the disassociation balance and the connective NH3 release. Also applied were the temperature difference (T from the house interior and air intake temperature, out of which the intensity of the air exchange through the slatted floor was calculated.

Results

Over four days in January *(fig. 1)* the simulation results showed a good agreement ,especially with the intensity of the measured ammonia emission. The day-time rhythm, with a lower emission in the first half of the day and a higher emission in the second, was also well reproduced by the model. The simulation results indicate in the main two increases in the ammonia emission in the afternoon and in the evening. The first can be traced to the influence of temperature on the release of ammonia, the second on the air exchange through the slatted floor between building interior and slurry canal. With the measurement results, however, only a rise in

Input parameters	Values and units	Source
General parameters		
Stocking	175 animals	known
Frequency of urinating	10 d^{-1}	estimated
Area of slatted floor/storage	230 m^2	known
Air volume under slats	230 m^3	known
Building volume	2000 m^3	known
Changeable parameters		
pH liquid manure in slurry canal	8,6	estimated
pH liquid manure under the slats	7,7	estimated
Ammoniacal N-content	April: 1,3 g/kg	estimated
	January: 1,4 g/kg	estimated
Urine content in urea	4,5 g/kg	estimated
Air velocity in slurry canal	0,1 m/s	measured
Air velocity over slatted floor	0,1 m/s	measured
Air volume flow through slatted floor	500 + 20 ΔT m^3/h, when$\Delta T>0$ 500 m^3/h, when DT<0	measured

Table 1: Specific input parameters for model calculations

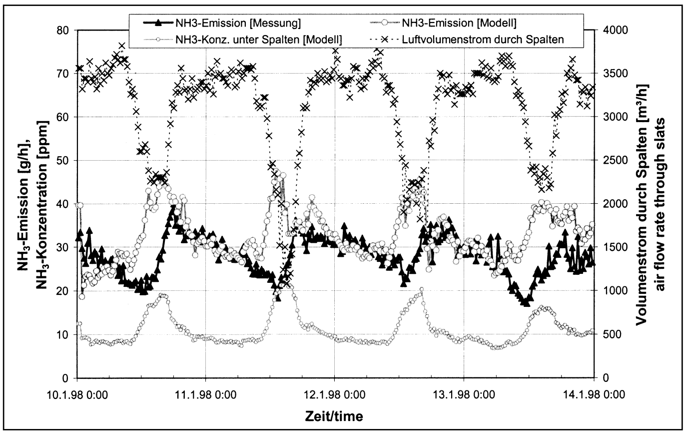

Fig. 1: Measured and calculated ammonia emission as well as calculated ammonia concentration under the slats and air flow rate through the slatted floor at four days in January (10 till 13. 1.1998)

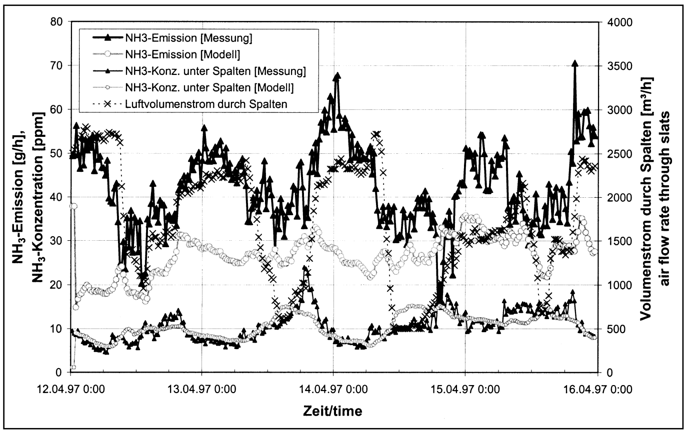

Fig. 2: Measured and calculated ammonia emission and ammonia concentration under the slats as well as calculated air flow rate through the slatted floor at four days in April (12 till 15. 4.1997)

ammonia emission in the evening was able to be established. It is probable that the increase in the ammonia emission as a result of the temperature rise, as well as the air exchange through the slatted floor, occurred at relatively the same time. The afternoon increase in ammonia emission was only able to be established by the simulation results.

A possible cause for the time advance of the temperature-caused increase in the simulation result could be that, in the model, the disassociation and release of ammonia is coupled to the interior temperature of the building instead of to the actually relevant slurry temperature. The latter ran badly because of the high heat capacity of the slurry and the floor, and was delayed compared with the building interior temperature – with which the temperature-regulated increase in ammonia emission also then started with a delay. The varying air exchange through the slatted floor between building interior and slurry canal was well reproduced by the model, but its influence on the time period is however less developed than the influence of the building interior temperature.

On the four April days in *fig. 2* the intensiammonia emission under utilisation of the same input parameters was clearly underestimated. The calculated ammonia concentration under the slats agreed well with the measurement results but the dynamic procedure, with a rise in the NH3 emission in the evening and during the night, was only unsatisfactorily reproduced.

Because of the deviation from the measurement results the model calculations for these April days were repeated, not with the determined standard values, but with the input parameters better suited to the actual conditions in the house (pH slurry on slatted floor: 8.1; air volume flow through slatted floor: 250 + 300((Tm3h). The simulation results in fig. 3 show that the level of the ammonia emission through the pH value increase now had a good agreement with the measurement results. Whilst the dynamic of the ammonia emission was also improved through the intensified air exchange through the slatted floor, the amplitude of the daily deviations of the measured ammonia emission where, however, not completely reproduced. Comparable with the January days in *fig. 1,* the calculated ammonia emission also raced ahead of the measurement values. The simulation results need to be improved through more intense consideration of the air exchange through the slatted floor and of the slurry temperature.

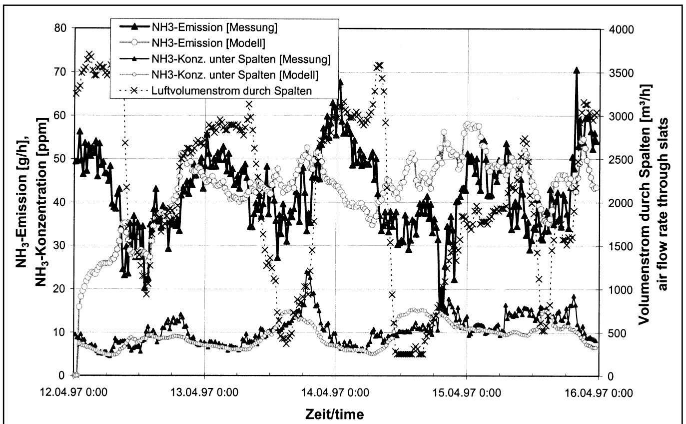

Bild 3: Gemessene und berechnete Ammoniakemission und Ammoniakkonzentration unter den Spalten sowie berechneter Luftvolumenstrom durch den Spaltenboden an vier Apriltagen (12. bis 15.4.1997) mit angepassten Eingangsparametern

Fig. 3: Measured and calculated ammonia emission and ammonia concentration under the slats as well as calculated air flow rate through the slatted floor at four days in April (12 till 15. o4.1997) with adopted parameters

Conclusions

With the simulation model here is presented a suitable instrument for estimation of the ammonia emission from dairy cow housing. Through using measured input parameters, or through sensible choice of parameters, the level of the ammonia emission can be realistically reproduced. With natural ventilation, the observation of the dynamic procedure of the ammonia emission must be made with special attention being paid to the air exchange through the slatted floor which leads to an intensified ammonia emission out of the slurry canal.

Literature

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