Krause, Karl-Heinz and Munack, Axel

All immission calculations depend on the correct initial concentration

There are difficulties of describing the near-to-reality emission situation at the time of release from animal husbandry. Thus, for example, a so-called predilution of the initial concentration cannot be drawn into the distribution calculation of the program AUSTAL2000G, but rather, only a "half truth" is given with the consideration of the emission mass flow. The administration has more or less committed itself to AUSTAL2000G; the proof of the correctness of the distribution simulation is often only the proof of the use of the said program. In many cases, more attention is paid to adapting the start situation to this model application than to considering the given laws of physics.

Keywords
Emission mass stream, source concentration, predilution, hedonic, animal specific weight factors, odor load

Abstract
Landtechnik 65 (2010), no 2 pp. 124-128, 8 figures, 5 references

The article "Animal specific corrections are placed wrongly in GIRL – proposals for a revision" [1; 2] is continued in this article. Based on an example using the calculation program AUSTAL 2000G [3] it is shown that the animal specific correction factors, postulated on the immission side, are reflected mathematically on the emission side as so-called Hedonic Factors. This gives rise to deal again with the basics of distribution calculations.

With the revision of the TA Luft [4] in 2002, the Gauss Model for distribution calculations of foreign substances in the air used at that time was replaced with the Lagrange Particle Model. Thus the transition from an analytical immission calculation to a numerical model was completed. Not carried through was an improvement of the technical model approach. The weaknesses lie in the point mass approach of both models: in the entire Gauss Model and, in the Particle Model, in the composition of the total mass through a multiplicity of particles with point level masses. After the particles are released, they are distributed into the surrounding area, whereby the location of each particle is determined by its trajectory. The trajectory is the connecting line of all places that a particle reaches in the atmospheric flow. In the Lagrange formula, a control volume ΔV moves with the flow. Related to the emission mass flow $\dot{M}_0$, an average immission concentration C results from the number of the calculated trajectories and the residence time of the individual particles Δt_n, while n $\Delta V/\Delta t_n$ denotes a volume flow rate:

$$C = \frac{\Delta t_n \dot{M}_0}{n \Delta V} \text{ resp. } C = \frac{\dot{M}_0}{\dot{V}_0} \qquad \text{(Eq. 1)}$$

If one sucks an air stream over an area A from the air flow loaded with particles on the edge of an obstacle, or adds polluted air into the system area, then one also achieves a concentration statement at the edge:

$$C = \frac{\dot{M}_0}{A\, v_{suck/add}} \qquad \text{(Eq. 2)}$$

At the source, the initial concentrations determine, by means of their exit speeds, the start of the distribution via the interface between stable and environment. In the air outside of the sources, the spatial particle distributions define, for example, the odors above or below the odor perception threshold of 1 GE/m³. GE stands for Odor Unit.

Individual Examples from Agriculture

AUSTAL 2000G is a program for distribution calculations using data from the emission side under consideration of the meteorological and topographical conditions on the immissions side. It is not a program to shape the emission behavior of agricultural sources. Thus systems with differing initial concentrations are difficult to differentiate in the program AUSTAL 2000G, particularly with equal emission mass flows. Furthermore, certain ventilation forms are not considered, even though they are well known in stable ventilation systems and in immission prognoses, for example side wall ventilators. **Figure 1** shows side wall ventilators on the gable side which primarily blow odorous substances against the wind. The concentration decrease through the wind, and thus the reduction in perceptibility, requires less distance, compared to a distribution via the roof. Even if such a solution is limited to special given factors, the practical implementation should not fail for the reason that the program AUSTAL 2000G does not include a ready solution for side wall ventilation. The case of wind-induced sources, meaning stables that are flooded with wind and show wind dependent emissions, shows a different story. These stables are a reality in cattle and poultry husbandry. That is why one cannot allow himself the luxury of ignoring them in terms of immission considerations. It must be noted, however, that the distribution calculations are carried out with the program AUSTAL 2000G using so-called emission factors, in which the given stables are re-functioned to those with forced ventilation. Although this is far from reality, it is justified as a pragmatic approach.

Fig. 1

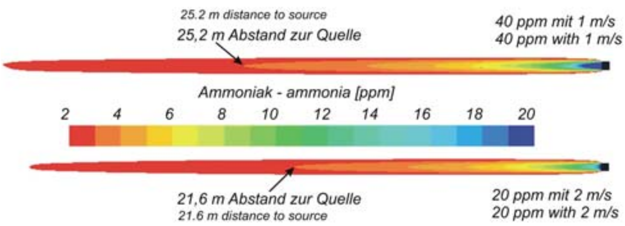
The ventilation stacks on the roof were removed. The blowing out of stable air on the gable side, 200 m behind the barn, leads to lower odour loads in comparison to the roof emissions with stacks

In **figure 2**, simulations of odor loaded ventilation streams are presented in which in each case the same mass flow is released but in which the initial concentrations and speeds differ. In the upper part of the figure the ammonia concentration is blown out with 40 ppm at 1 m/s, in the lower part with 20 ppm at 2 m/s. It becomes clear that the general distribution condition holds, that with increasing course length in the main wind direction the concentration is reduced. Even more: the concentration is much more quickly dispersed in the case of doubled blowing speed than with half the exit speed and double exit concentration. That means however that, in the source vicinity, differences in the immission concentration emerge, which must be taken into account. If one wants to include these approaches, one can only do this via a source carrying the initial concentation with the according abatement behavior. The extent of the false prognoses is especially clear if one, for example, calculates the odor level in the vicinity of sources that are emitting vertically and are covered by AUSTAL 2000G for annual considerations. Here, three cases are chosen related to the same mass flow: a) emission mass flow without consideration of a special source configuration, b) initial concentration of 350 GE/m³ at 6 m/s exit speed and c) initial concentration of 259 GE/m³ at 7.5 m exit speed. The isochromatic presentation in **figure 3** makes case c) appear to be the most favorable, while case a) leads to the highest pollution. A given emission mass flow from a point source leads in a transfer to a source with a finite diameter d and an exit speed v_0 to an initial concentration

$$C = \frac{4\,\dot{M}_0}{\pi\, d^2\, v_0} \qquad \text{(Eq. 3)}$$

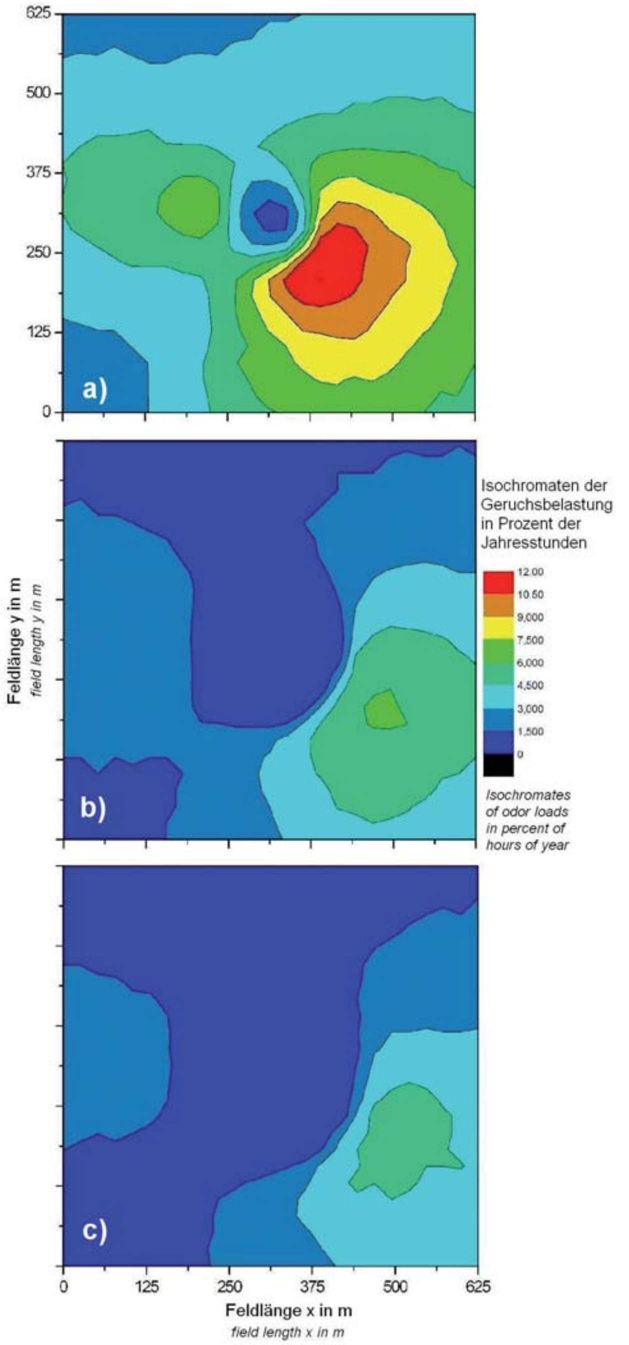
The exit speed v_0 thus determines the effective initial concentration with a pregiven emission mass flow and an exhaust pipe diameter. Since the exhaust pipes for emission sources do not float in the air, but rather are connected to building structures, the influences of these buildings occur in the vicinity of the source and lead to downwash effects. One cannot assume an undisturbed exhaust flow. Information Sheet 56 on the creation of immission prognoses [5] recommends considering this building influence with vertical line sources without a superel-

Fig. 2



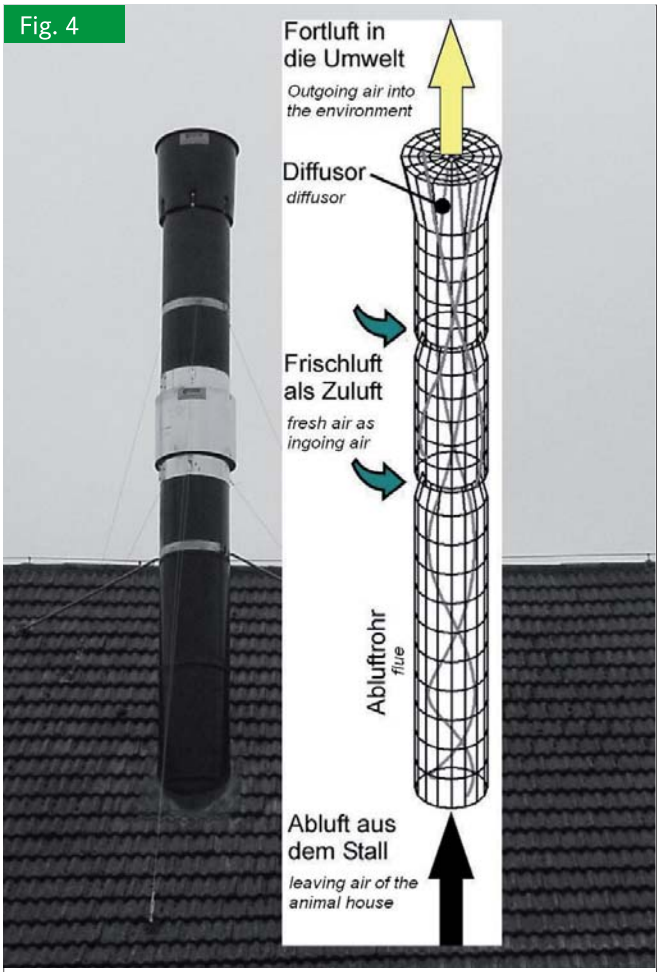
The effect of side wall ventilation as a free stream. In Case 1, the initial concentration is twice that of Case 2. The initial velocity is half as high. Near to the sources there are differences between the two expansion situations. From 40 m onwards, the concentrations in the stream centers are hardly distinguishable

Fig. 3



Total immission load in percent of hours of a year according to different source constellations:
a) with 333 GE/s, b) 333 GE/s with 350 GE/m^3 *and 6 m/s and*
c) 333 G/s with 259 GE/m3 and 7.81 m/s. In case a) the load areas are much closer around the animal plant than in case c)

Fig. 4



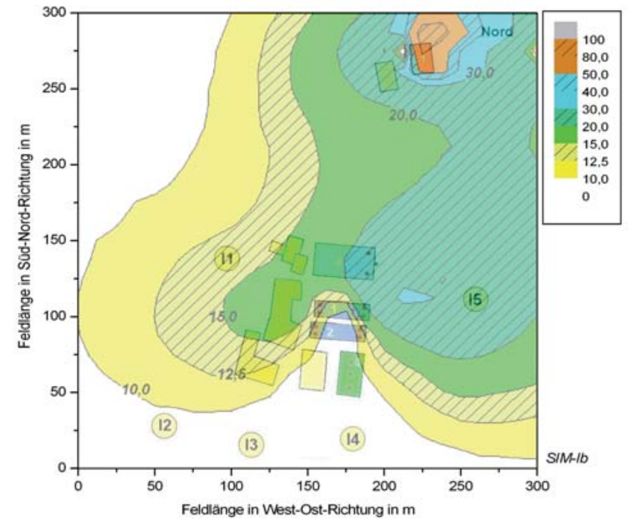
Realization of an exhaust system (left) according to the pump-principle of water jet (right) with wind protection over the radial suction slot

evation of the exhaust air stream. One must here make a clear distinction on what shall and what shall not be considered. On the basis of a point mass model, on the immission side it comes to a significant stress on the source environment, see part a) in **figure 3**. First the model behavior must be corrected with regard to the true concentration input at the source, see parts b) and c) in **figure 3**. In dependence of the various climate conditions, the differences in the course of a year amount to 100 m and more. How one deals with building influences should be clarified with the flow approach in the AUSTAL 2000G program. Important in the shown examples is the insight that, again and again, modifications in the source concentrations are encountered.

Pre-dilutions

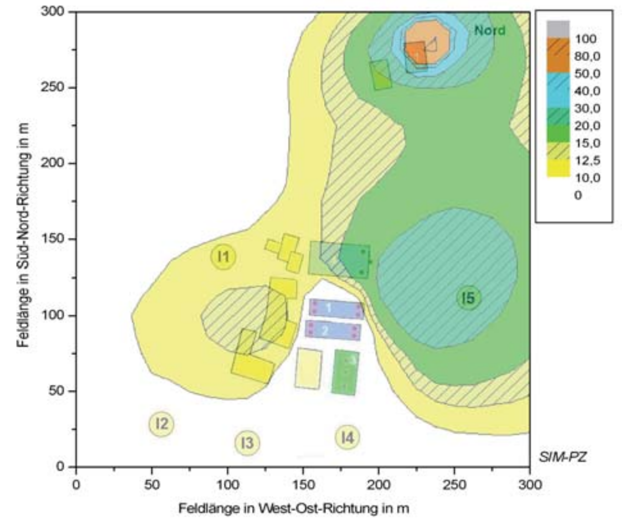
The reduction of the source concentration has the greatest influence on a reduction of the immission concentration and thus on the perceptibility of odors in the area surrounding a stable. The effect of the pre-dilution is thus stronger, the greater the relationship of the outgoing air mass to the exhaust air mass leaving the stable (**figure 4**). The emitted mass of odor substances remains equal, but the source concentration in the outgoing air is reduced. With the volume flow ratio the application of the continuity equation results in the outgoing air concentration diluted to the 0.625 level of the source concentration. The exhaust air concentration leaving the stable experiences a reduction of 37.5 %. When using the program AUSTAL 2000G to calculate this situation, only the emission mass flow enters the calculations whereby in the results the immission reduction created by the pre-dilution is not taken into account.

Fig. 5



Total immission load in percent of hours of a year according to GIRL without animal specific factors

Fig. 6



Total immission load in percent of hours of a year according to GIRL with animal specific factors. All areas of loads are located closer to the animal plants in comparison with load situation without animal specific factors

In the prognosis by the AUSTAL 2000G program, the predilution does not lead to immission reductions. One only comes further if one includes the source concentration and uses this to make an inference on the exhaust air speed.

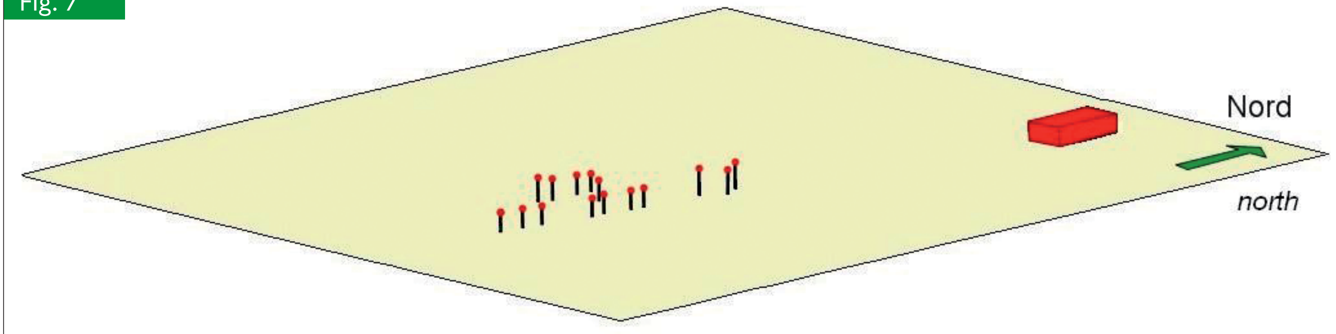
Source Environment in Focus

Different agricultural animal husbandry farms have an effect on the environment with their odor emissions. It must be tested whether healthy living conditions exist on the immission sites I1 to I5 (**figure 5**) if the farm at the center of the illustration were to build an additional stable with 1,300 fattening pigs using a partial filter. **Figures 5** and **6** show results with and without animal type specific factors. In **figure 7** the presented starting scenario differs strongly form the reality with trees (**figure 8**). If the given situation is ignored, or rather cannot be incorporated in a computer program, the defenders of the program speak of a "conservative solution." The emission load at immission site I1 is between 12.5 and 15 % hours of the year. The expansion measure is definitely acceptable. Using the animal type specific factors, the pollution value sinks to between 10 and 12.5 %. This can also be achieved through a reduction of the initial concentrations of the participating types of animal husbandries.

Conclusions

On the emissions side, among other things, measurements of odor concentrations via olfactometry are available. The model AUSTAL 2000G supported by the German Environmental Agency (UBA) does not use these and takes into account only the emission mass flows. Since this modeling of the emission side leads directly to the immission side, errors, as they doubtlessly occur in the vicinity of the buildings, are not charged to the distribution program. Rather, in the framework of a broad pragmatism, they are covered with alleged substitute systems and thus the blame is shifted to the emission side. If one takes the influence on the immission side with animal type specific corrections, one separates the causality chain of the emission via the transmission to immissions, and thus leaves the evaluation of the immission loads open to arbitrary interventions. The framework set for the admissability of loads is not a task for simulation technology, but external valuations must also be

Fig. 7



Only point sources and a volume source exist. The point sources are located at the head ends of vertical shafts, serving as position markers

Fig. 8

Neighbourhood formations in the vicinity of sources (here, a "green wall") that remain unnoticed

considered with regard to their causal analytic inclusion in regard to the logic. The animal specific correction factors reduce the source concentrations on the emission side in the sense of a Hedonic weighting. If, thus, inadequacies should be cushioned, then these must be included in understandable corrections

$$\dot{M}_{0,eff} = \dot{M}_0\left(f_{animal\ type\ specific} + f_{structures+} + f_{source\ concentration}\right) \quad \text{(Eq. 4)}$$

The effective emission mass flows from agricultural sources must be corrected, beyond the calculations based on the most simple cases (taking into account the specific mass flow and the animal mass), with the factors:

- animal type specifics
- structural documentation (in particular, surrounding impediments and vegetation)
- consideration of source concentrations

so that the program can be sensibly used in agriculture.

Literature

[1] Bund/Länder-Arbeitsgemeinschaft (LAI): Feststellung und Beurteilung von Geruchsimmissionen (Geruchsimmissions-Richtlinie, GIRL). www-hlug.de/service/download/luft/LAI-GIRL_2008_mit_Ergaenzung-10082008.pdf, Zugriff am 29.09.2008

[2] Krause, K.-H. und A. Munack: Tierartspezifische Korrekturen in der GIRL falsch platziert – Vorschläge für eine Neufassung. Landtechnik 64 (2009), H. 4, S. 276–280

[3] Janicke, L. und U. Janicke: Entwicklung eines modellgestützten Beurteilungssystems für den anlagenbezogenen Immissionsschutz. Im Auftrage des Umweltbundesamtes Berlin, 2003. Ibj/lj: austal2000/doc/report/public-2003-02-11, Zugriff am 15.03.2010

[4] Erste Allgemeine Verwaltungsvorschrift zum Bundes-Immissionsschutzgesetz (Technische Anleitung zur Reinhaltung der Luft – TA Luft) vom 24.07.2002. www.bmu.de/luftreinhaltung/ta_luft/doc/2594.php, Zugriff am 15.03.2010

[5] Landesumweltamt Nordrhein-Westfalen (Hrsg.): Leitfaden zur Erstellung von Immissionsprognosen mit AUSTAL2000 in Genehmigungsverfahren nach TA Luft und der Geruchsimmissions-Richtlinie. Merkblatt 56, 2006

Authors

Dr.-Ing. **Karl-Heinz Krause** is staff scientist at the Institute of Agricultural Technology and Biosystems Engineering in the Johann Heinrich von Thünen Institute (vTI), German Federal Research Institute for Rural Areas, Forestry and Fisheries, Bundesallee 50, 38116 Braunschweig, E-Mail: karlheinz.krause@vti.bund.de

Prof. Dr.-Ing. **Axel Munack** is director at the Institute of Agricultural Technology and Biosystems Engineering in the Johann Heinrich von Thünen Institute (vTI), German Federal Research Institute for Rural Areas, Forestry and Fisheries, E-Mail: axel.munack@vti.bund.de