Krause, Karl-Heinz and Munack, Axel

Animal specific corrections are placed wrongly in GIRL – proposals for a revision

In the course of authorization tests of animal husbandries regulations are applied, which deal, among others, with the odour problems. Besides respective guidelines of the VDI (Verein Deutscher Ingenieure; Association of German Engineers) also the Odour Immission Guideline (GIRL) of the LAI (Bund/Länder-Arbeitsgemeinschaft für Immissionsschutz; National/State Working Group for Immission Protection) in the February 29, 2008 version, amended on September 10, 2008 [1], subsequently referred to as GIRL2008, is applied. GIRL2008 carries with it a number of changes for agriculture. Village areas have been newly added as an evaluation area [2]. In addition, weighting factors have been introduced depending on animal types, leading to serious reductions in the extent of odour propagation. What was not permitted in former times may now be allowed. Some would greet this from a lobbyist perspective, other foresee an avalanche of hearings in civil and administrative courts.

Keywords
Dispersion calculation, odour load, immission prognosis, simulation

Abstract
Landtechnik 64 (2009), no. 4, pp. 276 - 280, 3 figures, 6 references

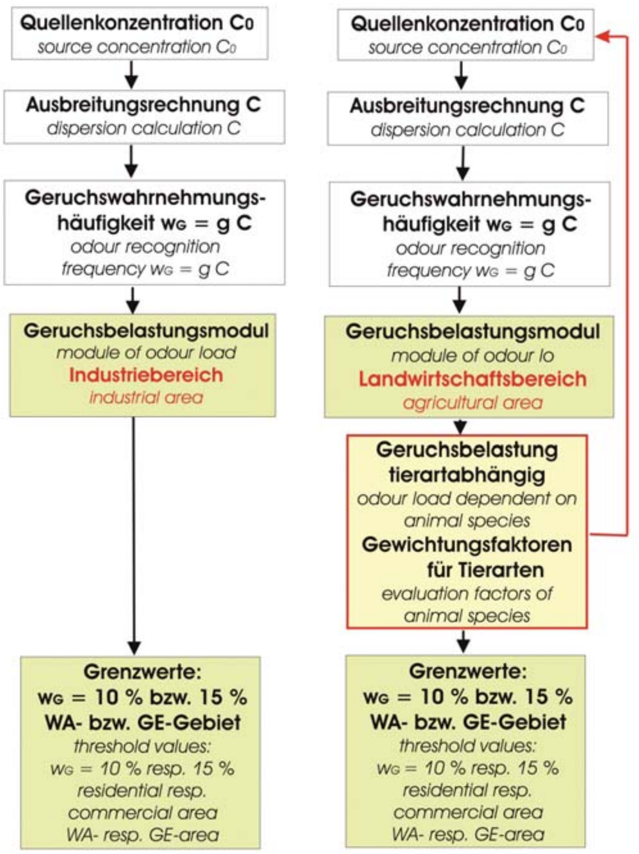
Until now, the calculations according to the GIRL went strictly from the source to the immissions side, see **figure 1**. Now a correction of the final results takes place. This putative adaptation to reality marks nothing else than an alteration of the emitted odour flow mass. Calculations by the program AUSTAL2000G, enforced by the GIRL, demonstrate that the recently introduced weighting factors depending on animal types lead to serious reductions in the extent of odour propagation. The program name gives hint to expansion calculation (in German: AU) after the German Technical Guideline on Air Quality Control (in German: TAL), issued in the year 2000 for odour substances (in German: G). Originally this program served for expansion calculations of ammonia.

The procedure of the determination of odour expansion includes a module for the propagation calculations with the AUSTAL2000G program and the source concentration as starting point, and a module for the load description by odour load in dependency on the frequency of odour registration. At the interface between the modules the calculated immission concentration is transferred into the odour recognition frequency w_B via a constant. The numerical particle model AUSTAL2000G, recommended by the GIRL2008, permits consideration of a great number of framework conditions as opposed to the analytical predecessor model, the so-called Gauss Model, and is doubtlessly an improvement. But there is a basic weakness in the numerical model, which relates to the transformation of average concentration values into odour recognition frequencies (interface between the dispersion and load modules).

Dispersion and load modules

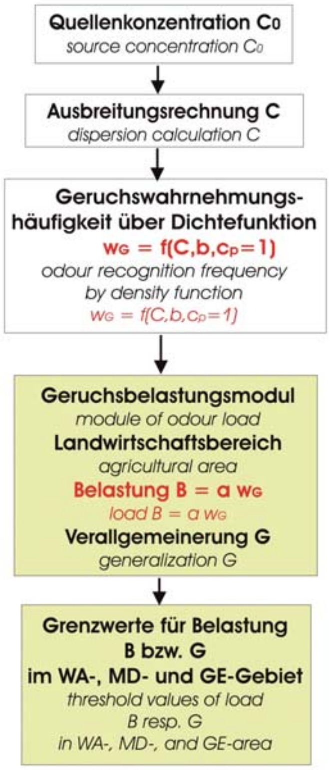
The mean concentration, subsequently referred to as C and referring to one hour, is numerically derived by the summation of the moving particles originating from the various sources and found at the immissions area to be studied. Other calculation programs, even those based on the Gauss model, determine the excesses using a density function between the concentration mean and the odour recognition frequency. This density function describes how particles are statistically distributed at a particular site (temporary concentration). In the AUSTAL2000G this takes place by multiplying the calculated mean value C by the factor g = 4 and comparing the product with the value 1. In the Gauss model, the factor is g = 10 (**figure 1**). The value 1 stands for the odour recognition limit, which is defined as 1 GE/m³. If the product is greater than 1, then a so-called „odour hour" exists, which is needed for further calculations, otherwise the product is set to zero. If one observes here the frequency of occurrence of the according meteorological situation, marked by wind direction class α, wind speed class U and dispersion class AK (turbulent influences), then the frequency w_G of the excess of the odour recognition limit can be determined. The odour recognition frequency presents the main basis for further calculations within the load module.

Fig. 1



Flow chart of the calculation of the odour recognition frequency and comparison with threshold values for different areas of usage. The propagation module is used to calculate the average immission concentration and the transformation to odour recognition frequency. The load module shows how the odour recognition frequency has to be interpreted and to be judged according to the determination of limits. On the left side the flow chart is shown which is used up to now and on the right side that of the GIRL 2008 with the feed-back shown in red.

Fig. 2



The well known procedure in the odour propagation module remains conserved. However, a density function is introduced at the intersection area between odour propagation module and load module. The load module is described in a new mathematical matter by using the load function B of the investigation project of odour assessment. There is a load function for each animal species that should be approximated by a general physical conncetion, e.g. an odour gradient G. The arrival of odours originating from different animal houses at the same time demands a special handling. So the odour propagation is calculated for each animal species seperately. The total load is the result of the addition of the single loads in conservative sense. In comparison with limits the impermissible area of load is determined.

Based on the conclusion that all animal husbandry odours essentially leave a negative impression [3], and hedonic differentiations are not appropriate, the authors of the GIRL2008 decided to introduce animal specific weighting factors f_i, (f_1 = 1.5 for poultry; f_2 = 0.75 for pigs and f_3 = 0.5 for cattle) in order to change the results of the dispersion calculation. To achieve this goal, a correction of the input data must be undertaken. The load module does not permit this, since no free parameters are available that could be included specific to animals within a function that specifies the load in dependence on the odour recognition frequency. If, then, one wants to change the results on the odour recognition frequencies, this cannot take place in the load module, as one is led to believe, but rather only in the dispersion model (see the following remarks).

Constant relation between C and w_G

The odour recognition frequency w_G at an immission site I is calculated via the excess frequency of the odour recognition limit at each mean immission concentration C, i.e. $g\ C_{\alpha,U,AK}$, and its frequency of occurrence $H_{\alpha,U,AK}$:

$w_G = w_{\alpha,U,AK} = g\ C_{\alpha,U,AK}\ H_{\alpha,U,AK}$ with $g\ C_{\alpha,U,AK} \geq 1$

If, now, animal specific weight factors f_i are introduced according to the GIRL, a new value $w_{\alpha,U,AK,2008}$ is obtained for the odour recognition frequency:

$w_G = w_{\alpha,U,AK,2008} = f_i\ g\ C_{\alpha,U,AK}\ H_{\alpha,U,AK}$.

If one combined the factors fi and g, then threshold values related directly to specific types of animals would result, which is an absurd idea. Since the immission concentration $C_{\alpha,U,AK}$ is linearly dependent on the emission concentration C_0:

$f_i\ C_{\alpha,U,AK}(C_0,R) = f_i\ C_0\ C_{\alpha,U,AK}(R)$,

it can be combined with the factors f_i. R stands for other dependencies. Then nothing changes in the existing model structure. Only the source concentration is modified:

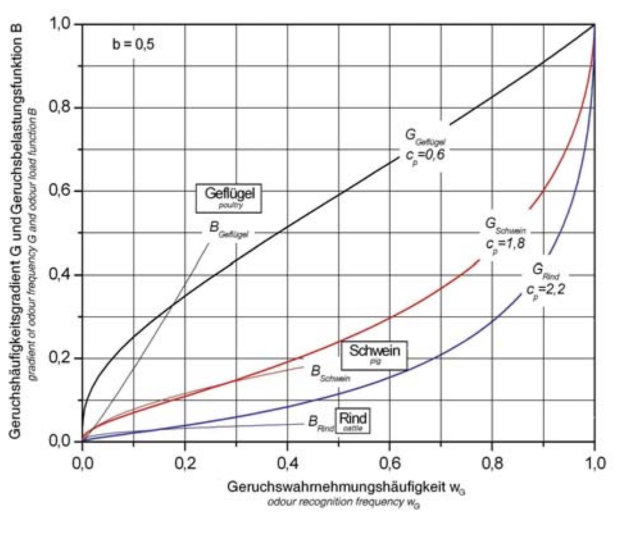
$C_{0,2008} = f_i\ C_0$.

One could express the opinion, that here the olfactometry is circumvented. First one calculates very meticulously the source concentrations in an olfactometric manner and then one deliberately estimates the expected load. The double meaning of the source strength can also be grounded with very simple pragmatism, as it is already expressed in guideline VDI 3474E [4]. Therein, the distance between animal husbandry and residential developments is determined by the odour relevant animal mass. In the guideline it is further stated that the animal herds are to be changed by a hedonic factor should it be necessary. Thus the odour relevant animal mass is reduced in cattle by the factor 0.7, while it increases in poultry keeping by the factor 2. Methodically nothing else happens in the GIRL2008. The hedonic is weighted to animal breed influences. The odour concentration in pig keeping is to be considered with the factor 0.75 before entrance into the dispersion calculations, the concentration in cattle keeping with the factor 0.6, etc. This approach offers the great advantage that the detailed algorithms for animal housing odours of different animal species of the GIRL2008 can be avoided. The rest of the immissions are presented in the already familiar manner. This is a first solution approach for a new version of the GIRL.

Reactions to odour loads

The results of the load module in the GIRL2008 are not very fruitful since the interactions found in the research reports are not given in further detail, besides the polarity diagram that does not find its way into concrete calculations. First with a reference to the research report [3] does one find information of the percentages for a „very heavy load“ divided into the three animal types, „poultry,“ „pig“ and „cattle“ in dependence of the odour recognition frequency. Numerically, the following relations can approximately be given, where B means frequency of heavy load and w_G is the odour recognition frequency. With a glance at **figure 3**, the frequency range from 0 to 1 is referred

Fig. 3



The gradient of odour frequency G and function of odour load B (of strongly load persons) in dependency of the odour detection frequency w_G. B comes from the recent research programme of the GIRL. For distinct parameters b and c_P the curves G are tangent to the B-courses of pig and cattle up to w_G < 0.3 or rather 0.2. For poultry the approximation is extremely bad.

to:

$$B_{Cattle} = a_{Cattle}\, w_G^{bCattle}$$
with $a_{Cattle} = 0.0577$, $b_{Cattle} = 0.36$

$$B_{Pigs} = a_{Pigs}\, w_G^{bPigs}$$
with $a_{Pigs} = 0.2899$, $b_{Pigs} = 0.57$

$$B_{Poultry} = a_{Poultry}\, w_G^{bPoultry}$$
with $a_{Poultry} = 2.218$, $b_{Poultry} = 1.1$

The loads present themselves as functions $w_G^{banimal}$ whereby the exponent banimal in the case of „cattle“ is the lowest, and rises via pig to more than 1 in the case of poultry. For the recognition frequency $w_G = 1$ (meaning 100%) the load by poultry grows to (more than) 100%, while in the case of pigs B = 0.29 (meaning 29%) results, which remains in finite values. A function where $w_G = 1$ leads to B = 1 would be plausible, as do the functions G in **figure 3**. Here, the main point is the principle estimate, considering the probability of error in the load data. The difficulty of surveying load reactions is not overlooked, [3], but all data that has a significant impact on the immission activity must be able to withstand plausibility tests.

Via the load function B, it was possible to derive weighting factors in GIRL2008. If one stops at the load functions and uses them directly, then it is possible to determine a separate load for each animal species at an immission site. To determine the total load, one can add the single contributions in a conservative manner. With the determination of load limits, one can then determine the surrounding areas that are classified as significantly loaded and are thus to be evaluated in the sense of § 3 BImSchG (Federal Immission Protection Act). With this approach, a shift in the evaluation of odour recognition frequency w_G leads directly to a load B. Here too, the mixed odours with physically doubtful distribution algorithms fall away. This presents the second solution approach for a new version of the GIRL described here.

Variable interactions between C and w_G

The load functions B are the result of research projects. Should one wish to approximate the subjective evaluations of those surveyed (residents and test persons) one must try to draw as many physical influences as possible into the considerations. This succeeds, to a limited extent, by introducing a density function.

As an example, the logarithmic normal distribution is chosen, as used in the program BAGEG [5]. Besides the averaged local concentration C it uses a free parameter b (the standard deviation of the logarithmic temporary concentration, ln c). So, just as one achieves the excess frequency of odour recognition thresholds by integrating the density function from $c_p = 1$ to infinity values for the temporary concentration, one also comes to clearly recognizable odours, if one sets the lower integration limit to a higher value as the odour recognition level, i.e., c_p = 1.1; 2; 3. However, then the frequencies of occurrence decrease. The excess frequency w_B of a concentration value c_p can generally be described as follows:

$$w_B (c>c_p) = [1 - \mathrm{erf}((0.5\, b^2 + \ln c_P - \ln C)/(\sqrt{2}\, b))]$$

w_G results in w_B for $c_p = 1$. Relationships of $w_B(c_p)/w_G$ for $w_G > w_B$ or rather, $w_G(c_p)/w_B$ for $w_B > w_G$ can be described as an odour gradient. In dependence of w_G, then in comparison with the load curves B, certain similarities of G for the lower range of w_G can be seen, see **figure 3**. The gradient for cattle keeping odours is less than for the pig husbandry odours. For poultry keeping farms, only vague information is possible. The curve approximation G leads to certain parameter combinations b and c_p. The parameter b is in general brought into context with the environmental structure [6], while the parameter c_p shows the lowest summation limit, above which the odours contribute to strong loads. c_p proves to be dependent on b, which can be evaluated in the case of existing facilities by registering the odour recognition frequencies in the animal husbandry environment. The use of approximations G provides the advantage to show a plausible behaviour pattern, in comparison to the functions B, at higher odour recognition frequencies. This is the third solution approach presented here for a new version of the GIRL.

Standard distribution calculations using the logarithmic normal distribution and only using w_G, assume $b = 0.5$, and then use limits of 0.1 and 0.15 or rather 10 and 15 percent.

Effects on practice

If one chooses a mathematical model, as was done for the GIRL in the National/State Working Group for Immission Protection (LAI), that only provides one case-specific parameter, namely the source concentration, then one cannot expect to explain other phenomena of odour distribution with this tool. The odour recognition frequencies found, via the load studies, to be too high in agricultural areas only lead (by animal specific weighting factors) to a change of the source concentrations, or rather the emission mass flows. In practice, the GIRL is here no different than the guideline VDI 3474E. There the emission determining animal mass is put under a hedonic weighting; here, the originally calculated olfactometric odour concentrations are put under a correction of weighting factors. There is no methodical difference. The consequence for the GIRL: new version, whereby the source input on the odour concentration together with the emission mass flows surrounding the weighting factors must be changed. All algorithms for assumed mixed odours fall away. This is a very pragmatic and quickly implemented method.

From the mathematical point of view the methodology of odour expansion leads to the derived consequence that the factors of animal breeds determined on the immissions area are directly reduced to the source concentrations. It is fact that the distances between dwelling houses and animal plants are altered: they become shorter for pig and cattle houses and greater for poultries because the levels of allowance of 10 % and 15 % persist further on. The whole jurisdiction, as it follows the GIRL, can work further on with the known limits. However, it is not scientifically comprehensible that the laws of the Federal States incorporate the weighting factors of the different animal species with different magnitudes (e.g. in piggery in Baden-Württemberg with the factor 0.6 and in Lower Saxony with the factor 0.75).

Another possibility is to use the load functions derived in the research project [3], here called B, to illustrate loads in dependence of odour recognition frequencies. With load limits, one then finds the necessary differentiation in the spirit of § 3 BImSchG. The simultaneous emergence of odour inputs at an immission site is calculated by adding the odour contributions, which emerge from the individual animal species or other sources. The evaluation system in GIRL shifts from an odour recognition frequency to a load. The GIRL continually points to an assumed "closed system" causing the interrelation between odour propagation and load reaction. So one should use this, at least as no other guidelines exhibit such interrelation.

Should one not be satisfied with the load function, B, but rather shift to approximation functions G, the density function is indispensable. One can include the inputs of clearly recognizable odours wB in the simulation. Otherwise, the previously described approach can be used.

Conclusions

The level of difficulty and complication increases in the series of described revision proposals for the GIRL. This should however not be an obstacle to stopping the current development errors in the GIRL. The quickest approach is to implement the first solution method. Just because the authors suggest changes to improve the GIRL, this does not mean that they accept all steps contained in the GIRL. The authors feel, however, obligated, in their capacity as representatives of a national scientific institute, to intervene on behalf of all participants when required by science.

Literature

[1] Feststellung und Beurteilung von Geruchsimmissionen (Geruchsimmissions-Richtlinie - GIRL) in der Fassung vom 29. Februar 2008

[2] Lang, M.: Die Vereinbarkeit der Gebietsdifferenzierung der Geruchsimmissions-Richtlinie (GIRL) mit den Vorgaben des BauGB/BauNVO. Natur und Recht, (2008) 29. S. 15-18

[3] Sucker, K., Müller, F. und Both, R.: Bericht zum Projekt Geruchsbeurteilung in der Landwirtschaft, LUA NRW, 2006

[4] VDI 3474E: Emissionsminderung Tierhaltung Geruchsstoffe. Beuth-Verlag GmbH, Berlin, 2001

[5] Krause, K.-H.: BAGEG und EMIAK – Alternative Methoden der Geruchsimmissionsprognose. In: Gerüche in der Umwelt. VDI Berichte 1373, (1998), S. 307/321

[6] Csanady, G.T.: Turbulent Diffusion in the Environment. D. Reidel Publishing Company, Dodrecht, Holland, 1973

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