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Cattle Housing Odour Emissions and Their Effects

Following the introduction of the cattle directive VDI 3474, people have used many methods in the evaluation of cattle housing. The permitted distance between domestic domiciles and livestock production is continually reduced the further south one goes in the Federal Republic of Germany. In the meantime a final report from a Ministry of Agriculture-supported research programme into the cattle housing situation [1] is available. According to this, the required minimum distance between cattle housing and human domiciles could be calculated via a variable odour equivalence factor.

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After the presentation of the draft of the directive VDI 3473''Emission reduction in cattle production" [2] there was criticism of the odour equivalence factors mentioned in the directive. For many, the factors appeared to be too large. The odour equivalence factors enable the calculations of livestock housing distance from human housing as already known in the pig housing directive VDI 3471 [3] to be applied to other livestock housing. The greatest resistance has appeared in Baden-Württemberg and Bavaria. Subsequently, projects aimed at demonstrating how the system works with regard to the distance between cattle housing and human domiciles have been financed with the support of the respective federal states [4,5]. Additionally, a publication from Schleswig-Holstein has appeared [6] which, in supplementation of the work from Baden- Württemberg, concerns itself with large-scale livestock production units. However, it is stressed in all the available publications that the distances according to the suggestion of directive VDI 3473 are too large, odour equivalence factors were not mentioned.

The odour equivalence factor feq is linked to the livestock mass MT and leads to the odour equivalence livestock mass MT,eq:

$$M_{T,eq} = f_{eq}\, M_T \qquad (1)$$

Together with the points awarded P to the housing system, whereby a maximum of P = 100 is permitted, the central distance relationship

$$r_{Grenz} = a(P)\, M_{T,eq}^{\,b(P)} \qquad (2)$$

a(P) and b(P) are polynomial in P and lead for P = 100 of a (P=100) = 48.697 and b (P=100) = 0.338. The central distance relationship continues to stay in the new directive VDI 3474 when, instead of the point-awarding, an awarding of notes is introduced through a so-called technology factor. Whatever is applied, one cannot get past the definition of an odour equivalence factor feq in the further development of the livestock production directive.

Formally, such a factor can be developed through the determination of a distance according to the specific type of animal $r_{GrenzRind}$. This uses the meter as unit when Mt is given in large animal units (1 GV = 500 kg). Where the distance relationship $T_{GrenzRind}$ is known, perhaps in the form

$$r_{GrenzRind} = A\, M_T^{\,B} \qquad (3)$$

then, through coefficient comparisons with the relationship (2) with regard to (1) for the required feq-factor takes place:

$$f_{eq} = 1/M_T[r_{GrenzRind}/a(P)]^{1/b(P)} \qquad (4)$$

Looking at the publication referred to initially one arrives, over particular conversions via [4], at:

$$f_{eq} = 0{,}0005983 \qquad (5)$$

via [5] at

$$f_{eq} = 0{,}064 \qquad (6)$$

via [6] at

$$f_{eq} = 0{,}27 \qquad (7)$$

Recognisable is the not inconsiderable distribution width of the odour equivalence factors. Within the Federal Republic one is far away from equal treatment in each state. The factors featured in the directive VDI 3473 mainly lie in line with the values according to equation (7).

Methodology

The thoughts behind the creation of VDI 3471 were aimed at determining the threshold of an odour distance rs for a particular livestock house. The odour threshold distance marks the site where, when the housing is approached against the wind, an animal-specific smell can be recognised for the first time. The investigations were carried out in the 70s with many inspections on over 600 pig housing units. The odour threshold distance was established in the inspections in each case as the result of a certain meteorological situation with distinct emission conditions and is independent from the number of times such situations took place. In order to reproduce the most unsuitable case, the area around the livestock unit must have been subjected to all the applicable conditions from wind velocity U, wind direction α and turbulence class AK. When the different meteorological parameters are classified, then one can base the calculations on $n_U = 7$ speed class, $n_\alpha = 12$ wind direction classes and $n_{AK} = 6$ turbulence classes from at least 7•12•6 = 504 combinations. In this case, a wind directional sector of 30° is taken.

It has to be doubted that the inspections at that time took regard of this aspect in all its nuances. Despite this the applicable distance declarations were, and still remain, suitable as anticipated evaluations before court and in other licensing procedures, for delivering a reliable basis for decisions. This does not mean, however, that as a direct result nowadays, one must also pass over deficits in data collection. On the contrary, with the refined methods in the data collection and evaluation it is possible to build further onto the VDI directives. In such cases the simulation technique is supported by inspections.

The natural science way is carried out through measurement, analysing and evaluation. On the emission side, volume flows from free-ventilated cattle housing are measured with the help of the tracer gas method. According to the "Rührkessel" theory the air exchange figure can be determined by tracer gas or indicator gas methods. The change in concentration of a known, evenly distributed source concentration of a tracer is recorded with concentration measurements at predetermined sites throughout the housing. Used as tracers are non-poisonous substances which have proved to have as small as possible background concentration in the housing and are easy to detect. With the measuring methods used here, the preferred gas is krypton-85. The tracer gas is fed into the housing in a once-only sudden introduction. At different defined sampling points, the diminishing rate of the initial concentration distribution is recorded simultaneously. From the rate of reduction, one can calculate the air exchange figure, and from this it is possible to work out the volume flow. With an average constant for the reduction rate, the volume flow is calculated out of the measurement values. With this one gets a average tracer-reduction function and air exchange figure for every sampling point.

The calculation of the source concentration is by olfactometry so that, together with the volume flow, the emitted odour mass flow is known. Parallel to this, the meteorological data are recorded. On the immission odours in the vicinity of livestock production, the impressions regarding odours are recorded with a portable computer with the operator punching-in reactions in a yes/no format.

For points assignation in the field, different odour recognition frequencies w_B were registered via the inspections. The directive VDI 3940 [6] says something about flag inspections but gives nothing concrete about the methods as to how one reaches a decision on odour threshold distance. Although here, there is very much evidence of an expansion simulation technique.

"*5.2.3 From a large number of flag measurements for different meteorological individual situations and different emitting types, values for the above mentioned parameters can be deduced and from these, expansion models be calibrated....*

5.2.4 The mathematical description of the expansion process for odour material in the atmosphere leads to prognoses of odour material emissions which agree with the reality."

It is barely possible to determine the te odour threshold distance from statistics alone. For this, the small number of inspections are not enough. One would make the same mistake that was already made in GIRL; there, it was attempted to calculate the annual surrounding situation regarding odour introductions with 26 or 52 inspections where a minimum of over 800 spot samples should have been made. In such cases, the choice of a shortcut means simply that reality is knocked out of the calculation.

In analysing the data, the coupling of the emission and immission aspects under given meteorological conditions with the help of expansion simulation is important: what counts is that the simulated frequency of recognition should be brought into step with the recorded frequency of recognition w_B. This approach is very time consuming. In comparison with the statistical system it is, however, still applicable in practice – and this is what everything depends on.

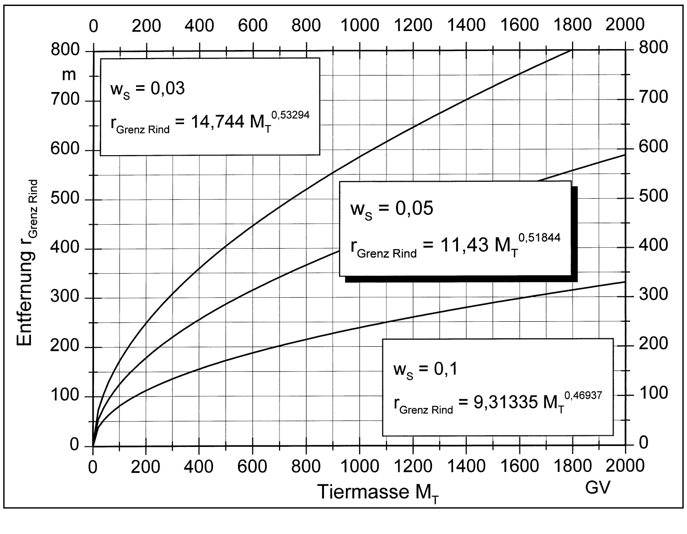

Fig.1: Graphic presentation of the relationship ascertained by the pairs of points (d_{max}, M_T) for $r_{GrenzRind}$

New odour equivalent factor

After the inspection calibration, one is in the position to determine the expected recognition frequency in relation to wind velocity U, wind direction α and the turbulence of the atmosphere expressed through the expansion class AK, according to Klug, in every site r in the vicinity of the housing . With a given animal mass M_T, with reference to a supposed emissions focal point, can be given the distance d_{max} to the point which lies furthest away, and on which especially the recognition threshold is overstepped. This has to be overstepped in that only w > 0 can be discovered too. As a result

$$w = w_S = 0,05 \tag{8}$$

is subsequently established.

In *figure 1* with the help of the error square method in the use of pairs of points (d_{max}, M_T) the resulting curve $r_{GrenzRind}$ is demonstrated. The analytical expression is available in figure 1 . Inserted in equation (7) follows with w_S according to equation (8)

$$f_{eq} = 0,0137691\ M_T^{0,533841} \tag{9}$$

For M_T = 50 GV one becomes f_{eq} = 0.11 for M_T = 500 GV feq = 0.38 and for M_T = 2000 GV f_{eq} = 0.8. These values deviate substantially where the livestock units are large compared with those that are mentioned in VDI 3473. Where the simulations are concerned, the open emission sources outside the animal housing (silage areas, middens, slurry pits) are not calculated. For evaluations, these have to be brought-in over equivalent source systems.

Literature

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