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Odour concentration and emission from naturally ventilated dairy loose housings with an outdoor exercise area

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Odour concentration and emission from five naturally ventilated dairy loose houings were compared in two seasons and at two times of day. A newly developed tracer ratio method with two tracer gases (SF_6, SF_5CF_3) was used for these stables with cubicles, solid floor surfaces and an outdoor exercise area arranged alongside the stable. Panel members were used to determine the odour concentration from area sources on the ground (cubicle, traffic aisle and outdoor exercise area) and at a height of 3 m on the olfactometer. Whereas at ground level the highest odour concentrations occurred mainly in the traffic aisles, the odour concentration at a height of 3 m was comparable over the three area sources in both seasons. This would indicate that at a height of 3 m there had already been considerable intermixture between these areas. In six of the seven measurement days odour emission in the afternoon was two to four times higher than in the morning. The variation in odour emission between farms was also very high, the median being 11-30 OU/LU·s. A comparative assessment of animal housing systems therefore requires broadly supported data on several farms, the inclusion of all seasons and high time-of-day resolution.

1. Introduction

Livestock farms and local residents converge in rural areas. Residential development is moving ever nearer to existing farms. At the same time village structures are changing. Contact between the resident population and farming – and consequently a high degree of understanding and tolerance of livestock farming – is on the decrease. Local government, cantonal authorities and courts are increasingly having to deal with grievances and complaints about odour nuisance from livestock facilities. When sites for livestock farming are selected, spatial planning requirements for the avoidance of sprawl and the prerequisites for long-term farm development leading to sizeable herds are often contradictory. Only when the ensuing discussion has been successfully translated onto a technical plane will the problem-solving approaches which best serve conflict avoidance and farm development bear fruit in the interest of animal farmers and residents. There is therefore a need for well-founded, up-to-date planning data to determine minimum distances between livestock facilities and residential zones, with a

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view to the targeted choice of sites for new buildings and extensions. Odour emission per animal or livestock unit (1 LU = 500 kg live weight) and per time unit is a suitable yardstick for the comparative assessment of livestock systems as well as an indispensable input variable for meaningful distribution modelling.

Whereas back in the 80's Oldenburg (1989) measured odour emissions from 17 cubicle dairy housing systems without taking account of the variation in time of day, Brose (2000) provided data of a higher chronological resolution, but only from a single farm. According to GIRL (2008) loose housing has posed problems in distribution modelling to date, as emissions depend on weather conditions (e.g. inflow velocity and direction). Emission factors for naturally ventilated systems should therefore be determined with particular care. A broadly supported up-to-date data basis of relevant processes from an adequate number of farms is essential. So far there has been a complete lack of data on cubicle loose housing systems with outdoor exercise areas as a source of floor-level diffuse emission, although this type of housing system is currently becoming very popular in Switzerland. The dearth of data on naturally ventilated stables is due mainly to problems in determining the air exchange rate.

The aim of this study was to compare the odour concentration of various area sources and to quantify odour emissions from cubicle dairy loose housings with outdoor exercise areas, highlighting the variation between two times of day and two seasons as well as between farms.

2. Methods

Measurements were taken in five loose housing facilities for dairy cattle (farms 2-6) with cubicles, solid floor surfaces and adjacent outdoor exercise areas. Figure 1 shows the ground plan of a farm by way of example. The different cowshed areas – traffic aisles, cubicles and outdoor exercise area – have been differentiated.

A comparison was made between two seasons, spring and summer (Tab. 1), in each case in the early morning (between 4:00 and 5:30 hours) and late afternoon (between 15:00 and 16:30 hours). Farm 6 was represented in both seasons, on Farm 2 measurements were taken on two days in summer. The present odour surveys were incorporated into studies carried out on six farms by Schrade (2009) on "Ammonia and PM10 emissions in naturally ventilated dairy loose housing with an outdoor exercise area based on a tracer ratio method". Farm data, housing systems and animal parameters are described in detail by Schrade (2009). Climate data, time spent by the animals in the outdoor exercise area and traffic area soiling were also recorded for the characterisation of each measurement situation, as reference values and for the derivation of important influencing variables on the emissions.

A sampling hood (home-made, diameter 845 mm) was set up consecutively on each of the different ground-level area sources and for 20 seconds an air sample was sucked into a Nalophan bag (9 litres volume) with an ECOMA sampler. The individual sampling sites in the traffic aisle, cubicle and outdoor exercise area were preset on the survey grid to avoid the subjective selective choice of each sampling point (Fig. 1).

Table 1 Data on the farms investigated, surface and herd numbers, and on survey dates and temperature data

Farm	Farm 2	Farm 3	Farm 4	Farm 5	Farm 6
Total area [m^2],	575	858	412	529	568
of which traffic area	440	624	295	377	388
Animals, number LU [n]	58	94	40	77	90/83
Survey date [month]	2 dates, August	March	April	June	May, June
Air temperature [°C]	12.6/22.8	5.5/20.5	9.3/7.4	13.1/19.6	9.6/20.6
Morning/afternoon	14.0/24.1				13.1/25.5

Odour concentration at ground level was compared with the odour concentration at a height of around 3 m (Fig. 1). An air collection system made from Teflon tubing and critical glass capillaries was used for the samples taken at a height of 3 m. The critical glass capillaries were positioned in a distance of 3 meters. This permitted representative sampling of the tracer gases and odour samples in the spacious stables. For composite air sampling each odour sample was sucked into the relevant sample bag with a peristaltic pump over an 8 minute time interval. Within 24 hours each of the 81 sample bags was assessed by four panel members on the TO8 olfactometer (ECOMA) in compliance with DIN EN 13725 (2003). N-butanol (100 ppm) was used as a reference substance.

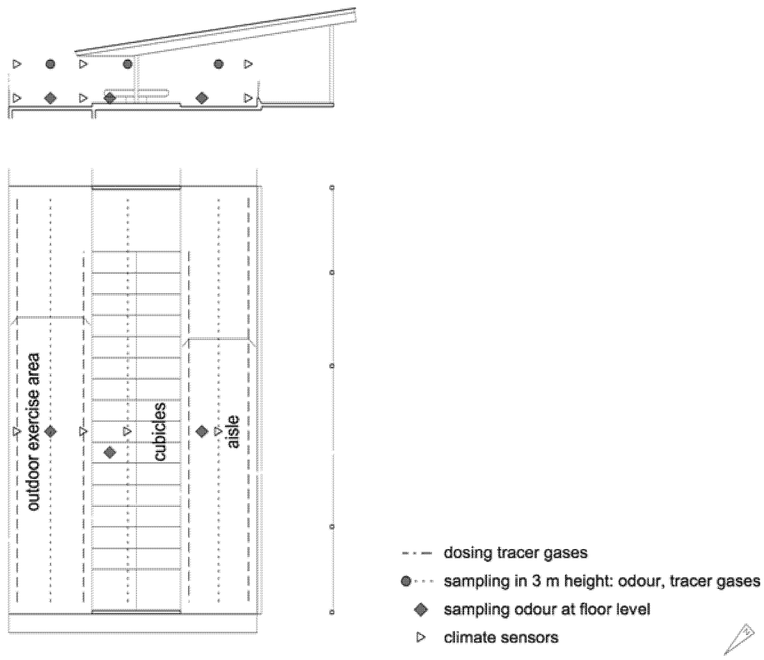

Figure 1: Schematic diagram with ground plan and section of double-row cubicle loose housing with dosing, sampling and climate sensors.

To determine the emissions with natural ventilation and from area sources, ART and Empa developed a tracer ratio method with two tracer gases (SF_6, SF_5CF_3). The diluted tracer gases were continuously dosed to the emitting areas by way of a pipe system with critical capillaries, thereby mimicking the source of odour emission. Analysis of the two tracer gases was carried out simultaneously using gas chromatography (GC-ECD). Odour emission can be determined from the concentration ratio of the dosed tracer gas at floor level and at a height of 3 m, multiplied by the odour concentration.

3. Results and discussion

3.1 Various ground-level area sources

In a comparison of odour concentration in the three stable areas the values from the traffic aisles, with a median of 870 OU/m^3, were considerably higher than those from the cubicles, at less than 150 OU/m^3, or from the outdoor exercise areas at 70 and 435 OU/m^3 respectively (Fig. 2a). This reflects the areas where animals spent most time and the corresponding occurrence of faeces and urine in the traffic aisle compared with the outdoor exercise area (Schrade, 2009). However individual values were spread over a wide range. This is illustrated, for example, by the fact that odour concentration on the ground reached values of up to 4000 OU/m^3, whereas 50 % of all the values were under 400 OU/m^3. Except for Farm 4 odour concentrations in the afternoon were higher than in the morning. The deviation in behaviour of Farm 4 is probably due to precipitation on the survey date (3 mm in the morning, 12 mm in the afternoon).

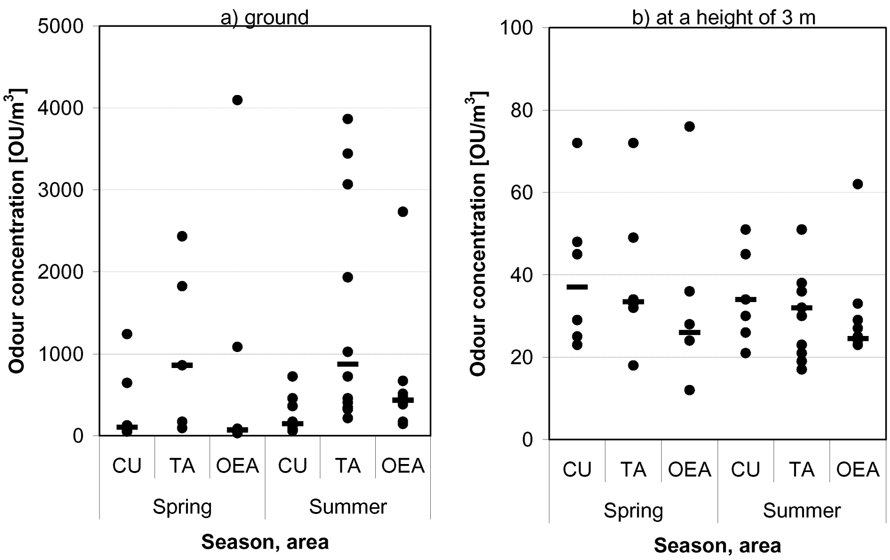

Figure 2: Odour concentration results a) on the ground and b) at a height of 3 m [OU/m^3], by season and stable area (CU cubicle, TA traffic aisle, OEA outdoor exercise area).

3.2 Composite air sample at a height of three metres

Spatially and chronologically the composite air samples taken at a height of 3 m are much more strongly averaged than the samples taken using a hood on the ground. Whereas on the ground the highest odour concentrations occurred mainly in the traffic aisle, odour concentration at a height of 3 m was similar between the two seasons and three areas (Fig. 2b). The median over all areas was between 25 and 37 OU/m^3. This would indicate that there was already considerable intermixing between these areas at a height of 3 m. The composite air samples at height allow something to be said about the whole stable area, whereas samples taken with the hood at ground level reflect only a very isolated segment. With sampling hoods a significantly greater number of samples would be required for the adequate spatial characterisation of heterogeneously soiled areas, particularly the outdoor exercise area, as this was particularly the case in the exercise yard (Schrade, 2009).

3.3 Odour emission

In Figure 3 odour emission is broken down into two points in time, morning and afternoon: in six out of the seven measurement days odour emission in the afternoon was two to four times higher than in the morning. This effect was only absent in the case of Farm 4, where there was precipitation during the survey. This great difference in the time of day may be caused firstly by differences in animal activity, in the airflow over the soiled area, and also by temperature differences.

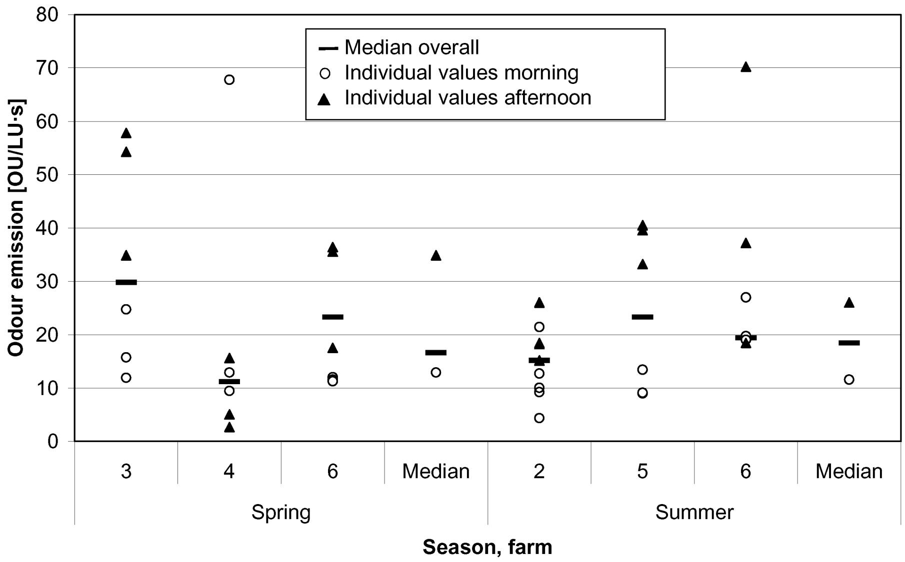

Figure 3: Odour emission results [OU/LU·s] as individual values morning and afternoon, illustrated per season and farm and as a median of the farms and per season.

The variation between farms was also very high, with a median of 11-30 OU/LU·s. On the day with precipitation Farm 4 had the lowest odour emission. The highest values were found on Farm 3 in spring. Farms 2 and 6, with the highest air temperatures in summer, did not produce the highest odour emission values. Figure 3 shows no apparent distinct seasonal effect as in the data on ammonia emissions in Schrade (2009) on the same farms. Odour emission in the present study, with open housing, larger surfaces and outdoor exercise aeas, was higher than in the literature, where the stables tended to be closed with eave to ridge ventilation (Oldenburg, 1989, Brose, 2000).

4. Conclusions

The new tracer ratio method combined with odour samples makes it possible to quantify odour emissions in naturally ventilated stables. An improved data base of odour emissions from the five naturally ventilated stables with outdoor exercise areas serves firstly as a planning aid for determining minimum distances between livestock facilities and residential zones, and secondly as a basis for extension modelling. A comparative assessment of livestock housing systems is possible only with broadly supported data on an adequate number of farms, the inclusion of all the seasons and surveys of higher chronological resolution, since dynamic processes involving animal activity, manure scraping, wind flow and drying out are relevant to odour emissions in naturally ventilated stables. An improved knowledge of the most important variables influencing odour release will help steer the way to odour reduction.

Reference

Brose G., 2000, Emissionen von klimarelevanten Gasen, Ammoniak und Geruch aus einem Milchviehstall mit Schwerkraftlüftung. VDI-MEG-Schrift 362, Hohenheim University.

DIN EN 13725, 2003, Air quality – Determination of odour concentration by dynamic olfactometry.

Odour Emissions Guideline GIRL, 2008, Determination and assessment of odour immissions. Edition dated 29.2.2008 and supplement dated 10.9.2008.

Oldenburg J., 1989, Geruchs- und Ammoniak-Emissionen aus der Tierhaltung. KTBL-Schrift 333, Darmstadt.

Schrade S., 2009, Ammoniak- und PM10-Emissionen im Laufstall für Milchvieh mit freier Lüftung und Laufhof anhand einer Tracer-Ratio-Methode. VDI-MEG Schrift 483, Kiel University.