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PAPER

ODOUR CONCENTRATION OF VARIOUS EMITTING AREA SOURCES FROM CATTLE FARMS

Authors
M. Keck[1], M. Keller[1], S. Schrade[2]
[1]Agroscope, Competitiveness and System Evaluation, Tänikon 1, 8356 Ettenhausen, Switzerland
[2]Agroscope, Ruminants Research Unit, Tänikon 1, 8356 Ettenhausen, Switzerland

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Abstract

Cattle farms consist of various spatially extended odour-emitting areas representing ground-level diffuse odour sources. These include loose-housing systems with outdoor exercise areas, the supplied diet, and storage areas for silage, slurry and solid manure. The aim of this study was to identify relevant odour sources on cattle farms and to compare the odour concentrations of individual sources, bearing in mind descriptive parameters. Compared with hay and sugar beet pulp (mean: <750 OU_E m^{-3}), higher odour concentrations resulted from the cut surface of grass silage (3990 OU_E m^{-3}) and maize silage (1690 OU_E m^{-3}) in the stores as well as from the mixed ration with silage on the feed table (2955 OU_E m^{-3}). Samples from the solid floors in the cattle housing (feeding and cubicle access aisles, outdoor exercise area) and from solid manure stores showed higher odour concentrations (1485 resp. 1845 OU_E m^{-3}) than littered areas such as cubicles and deep-bedded areas (<500 OU_E m^{-3}). The variation in odour concentration within the individual types was particularly large for grass silage, maize-and-grass-silage mixed ration, the solid-floor surfaces and the solid manure. On four farms, the odour-reducing effect of the natural crust on the slurry stores was evident compared with slurry stores after crust removal. These results improve our understanding of odour-emitting areas according to size, type, and farm management. Additionally, the findings of the large variation within individual odour sources offer a starting point for mitigation.

1. Introduction

In some cases, authorities have considered cattle husbandry as non-odour relevant or less odour-relevant than pig or poultry husbandry, and use various species-specific weighting factors to assess odour (GIRL, 2008). However, animal-friendly husbandry systems, changed operating approaches and larger farms are increasingly leading to other or larger diffuse area sources (Keck et al., 2018; Keck et al., 2019). Hooiveld et al. (2015) have determined comparable levels of odour nuisance to residents from cattle-farming when compared to pig and poultry farming, contrary to previous expectations based on odour emission models. Odour sources are many and various, ranging in cattle husbandry from feed storage, removal and distribution, to the areas in the housing used by animals, including dung removal, all the way to farmyard-manure storage. These are permanently present odour sources, characterized by different mixtures of numerous odour-active substances in varying concentrations. To date, few systematic details on the odour concentration of various area sources in cattle husbandry are available in the literature. The aim of this survey was to identify odour-relevant area sources from cattle husbandry in order to derive measures for odour reduction.

2. Materials and methods

To compare different odour sources, air samples were collected on commercial farms with cattle husbandry from various areas such as the feed store, livestock enclosure and farmyard manure store (Table 1). This created a broad information base for a relative comparison of the odour concentrations of various area sources. Air, surface and internal material temperatures were determined as descriptive parameters. In addition, the soiling level of the solid floors was assessed visually on site and subsequently with the aid of comparative photos.

Table 1: Experimental design: farms and odour samples from the various area sources

Area	**Odour samples from n farms / n samples in total**		
Feed store	Hay 4 / 11 Sugar beet pulp 5 / 6	Grass silage 5 / 8	Maize silage 6 / 6
Mixed ration		Grass & maize silage 8 / 12	
Flooring	Cubicles 7 / 12 Solid floor 14 / 57	Bedded sloped floor 2 / 6 Perforated floor 7 / 20	Deep litter 10 / 15
Farmyard manure	Solid manure 16 / 21	Liquid manure 4 / 8	

Air samples were collected by ventilated hoods EVH (ECOMA GmbH, Honigsee, Germany) with an upstream active carbon filter and CSD 30 sampling device (ECOMA GmbH, Honigsee, Germany). They were placed on the sites and the sample air was generally collected over a 30-min. period (VDI 3880, 2011). Individual samples were taken for homogeneous sources and mixed samples for heterogeneous sources at up to three sampling sites in each case by moving the hood. For the sampling on the surface of the slurry silos, the sampling hood was additionally equipped with floaters for liquids. Nalophane sampling bags with a bag-in-bag system served to ensure the stability of the samples and prevent gas exchange.

Odour concentration was assessed on the same day between 2 and a maximum of 9 h later according to EN 13725 (2003), with four assessors in each case using the TO8 olfactometer with the ‘yes/no’ method (ECOMA GmbH, Kiel, Germany). The results were identified as odour concentration per cubic metre [OU m^{-3}]. The suitability of the assessors in terms of accuracy and repeatability was tested with n-Butanol (EN 13725, 2003), whilst the threshold estimate was tested with hydrogen sulphide (VDI 3884, Part 1, 2015).

The odour concentration is represented graphically as both an individual value and a mean, with an indication of the survey scope n. Where there were a small number of samples (n < 5 samples) for liquid manure, the median was used. The data on the soiling level of the floors was represented with boxplots, median and mean in order to show the spread starting from the individual values.

3. Results and discussion

The odour concentrations for the samples with hay (530 OU_E m^{-3}) and for silage with sugar beet pulp (730 OU_E m^{-3}) were lower than those for the cut surfaces of grass or maize silage in the flat silo (3990 and 1690 OU_E m^{-3}, respectively; Fig. 1). Whilst a compact cut surface is also aimed for in the horizontal silo during silage removal, the mixed-ration feed is loosened after the removal and mixing process. This accounts for a larger surface area when distributed to the animals in the housing. After distribution on the feed table with grass and maize silage, the mixed rations yielded 2955 OU_E m^{-3} on average, but with a very large spread (610-7300 OU_E m^{-3}). Studies by Feistkorn et al. (2013) showed on the one hand that there was a strong seasonal effect with silages, and on the other that freshly deposited material led to substantially higher odour scores.

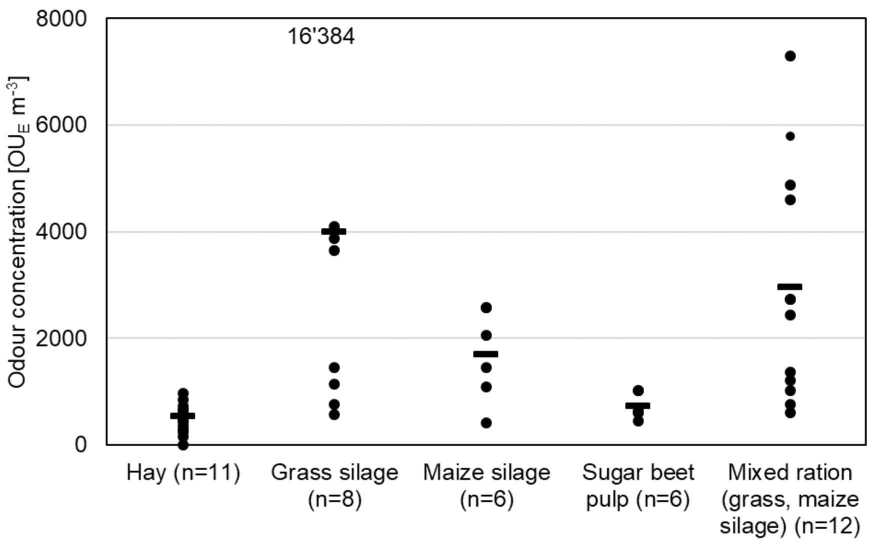

Fig. 1: Odour concentration of feed storage areas and the mixed ration provided.

In the lying area, deep-bedded cubicles with straw-manure mattresses, fermentation residues and combinations of straw and fermentation residues were aggregated for the cubicles (Fig. 2). At 205 OU_E m^{-3}, the mean of the cubicles was slightly less than that of the lying areas with deep litter (265 OU_E m^{-3}) and bedded sloped floor (495 OU_E m^{-3}). Flooring samples consisted of those taken in the traffic alleys in the housing, i.e. in the feeding aisle and cubicle-access area, as well as in combined feeding aisle / cubicle-access areas and in the outdoor exercise area. The average odour concentration for solid floors was 1485 OU_E m^{-3}. The individual scores were spread over a very wide range, reaching a maximum of 6135 OU_E m^{-3}. Floors thus have significantly higher odour concentrations than areas such as cubicles or bedded sloped floors/deep-litter areas. The control elements of the cubicles ensure that dung and urine do not accumulate over the entire bedded area, but at most outside of or along the curb board. As part of cubicle care, fresh dung is covered or mixed with litter. Urine drains away quickly when there is sufficient litter in deep-bedded cubicles. By contrast, fresh dung constantly accumulates on the flooring, remaining exposed on the ground.

A visual differentiation of the floor surfaces according to state and soiling level yielded a clear gradient of odour concentration, above all between wet or damp floors and dry ones (Fig. 3). This result shows the impact of quick urine drainage and frequent dung removal on permanently present odour sources in the livestock enclosure. Whether or not this effect is demonstrable on both the emission and impact side remains to be clarified. In line with studies from pig production (Keck et al., 2004), a differentiation of odour concentration according to soiling level was also shown for flooring in cattle housing.

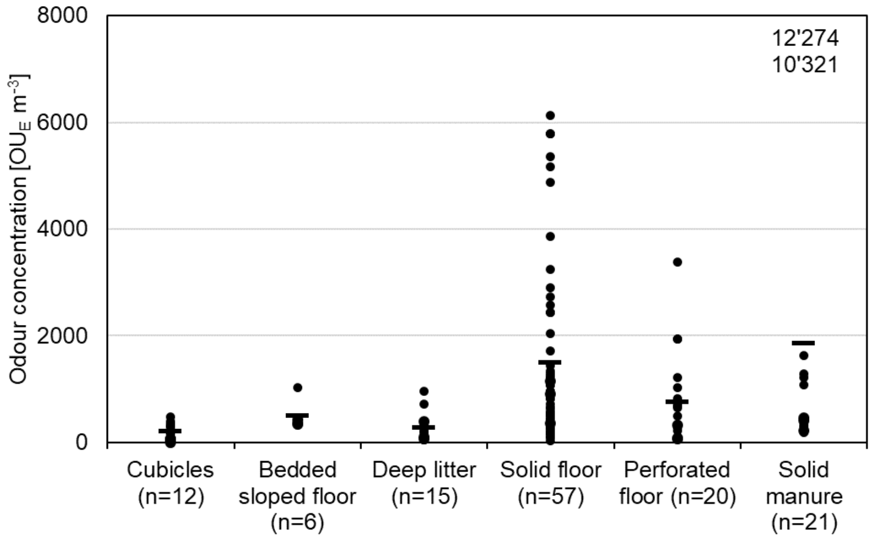

Fig. 2.: Odour concentration of lying area, floor and solid manure

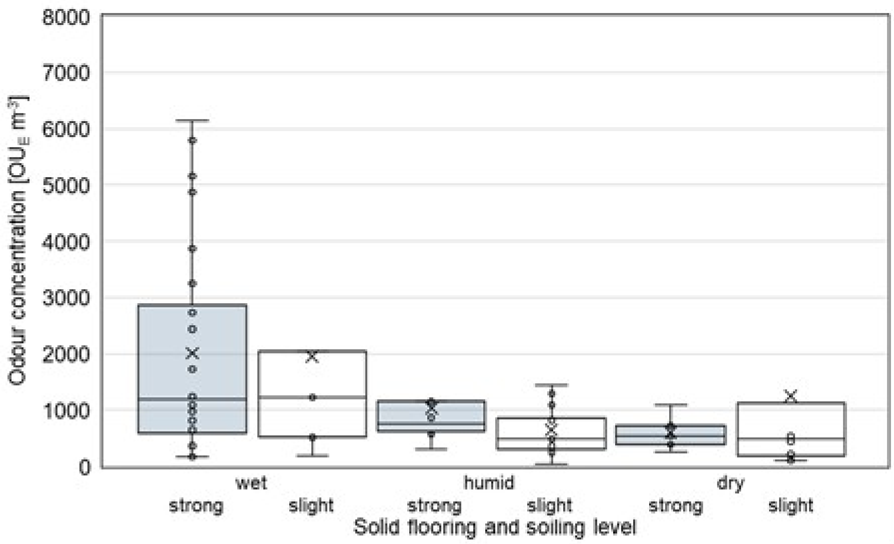

Fig. 3.: Odour concentration of solid floors, differentiated according to soiling levels.

Solid-manure stores (1845 OU_E m^{-3}, Fig. 2) and cattle-slurry (Fig. 4) produced high odour concentrations. In the situation with the crust, the air samples from the surface of the slurry silos on the four studied farms A-D reached odour concentrations of up to 5800 OU_E m^{-3}, and up to $11{,}585_E$ OU m^{-3} with removal of the crust, in each case with a large spread between the four farms. The odour-reducing effect of a natural crust could be seen clearly, with a reduction of between 45 and over 90%. It should be noted that at the times of the survey, the surface of the crust had dried owing to the weather. This clear reduction effect cannot be expected to the same extent in situations following precipitation events, after stirring the slurry, or with perforated floors, if there is a constant input of fresh manure.

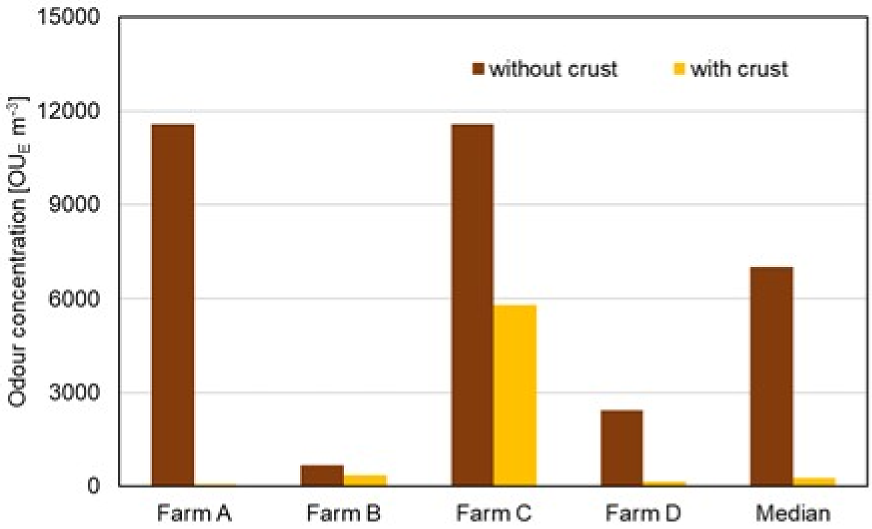

Fig. 4.: Odour concentration from slurry storage (individual values), without and with a natural crust.

4. Conclusions

Cattle husbandry is characterised by this great variety of individual odour sources, and must therefore be considered in a differentiated manner with regard to odour on individual farms. The storage areas for silage, slurry, farmyard manure, and in particular the flooring of animal housing are all area sources with higher odour concentrations. Both the large spread of the flooring scores and the high percentage of total surface area on farms represented by the flooring in cattle-housing constitute important starting points in terms of odour reduction. These can be linked to the size, arrangement or design of flooring, as well as dung-removal technique and frequency. Improvements could be achieved by better silage quality, less silage effluent, less warming and less remains of silage on the feed table. With reference to residents, the focal point lies on the impact side. Thus it is important to investigate in the future whether the complexity of the various odour sources is reduced with distance, which odour sources and odourants are perceptible on the impact site and which targeted steps reduce odour.

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