New Standards for Odour Emissions from Pig Facilities in Denmark

A. L. Riis
The National Committee for Pig Production, DANISH BACON & MEAT COUNCIL,
Copenhagen, Denmark

Abstract

The aim of this study was to determine the average odour emission from the most common pig facilities in Denmark during the summer in order to find new standards for odour emissions. The summer period was selected as odour emissions from finishing pigs was found to be highest during this period and is of great concern during public administration in the regulation of air pollutants.

To determine the odour emission from the nine most common categories of pig facilities in Denmark, 216 odour samples were collected. The nine categories of pig facilities were: dry sows kept in individual crates with partially slatted floors, dry sows kept loose, lactating sows kept in individual crates with partially or fully slatted floor, respectively, weaners kept in pens with partially or fully slatted floor, respectively, and finishers kept in pens with partially slatted, fully slatted or drained floor, respectively. Each category was represented by four intensive pig units, which all were mechanically ventilated. Odour samples were collected from each unit on three days with two samples per day. The samples were collected from the exhaust ventilation air in Tedlar® bags, and odour concentration was determined by an accredited odour laboratory. The ventilation rate of each house type was measured by a Fancom measuring fan.

The odour emission from dry sows did not differ significantly between the types of facility. This was also observed for weaners and therefore one number for odour emission is given for each of these stages of production. No difference was found between fully slatted floor and drained floor in finisher facilities. The odour emissions given in $OU_E\ s^{-1}$ animal^{-1} were 16 for dry sows, 72 for lactating sows with partially slatted floor, 100 for lactating sows with fully slatted floor, 7 for weaners, 19 for finishers with partially slatted floor and 29 for finishers with fully slatted or drained floor.

Furthermore, the ammonia concentration was measured in the exhaust ventilation air by Kitagawa Gas Detector Tubes at each odour sample. The ammonia emissions were 10.9, 13.4, 25.3, 0.1, 1.7, 4.6 and 6.2 g d^{-1} animal^{-1} for dry sows, lactating sows with partially slatted floor, lactating sows with fully slatted floor, weaners with partially slatted floor, weaners with fully slatted floor, finishers with partially slatted floor and finishers with fully slatted or drained floor.

Introduction

In cases concerning air pollution with odour from livestock buildings in Denmark, emission standards for odour based on measurements from German livestock buildings in the 1980s (Oldenburg, 1989) have been used so far. Consequently, there was an acute need for emission standards of odour measured in Danish livestock buildings in 2005. Therefore, as part of the Agreement on the Action Plan for the Aquatic Environment III 2005-2015 in Denmark (Danish Ministry of the Environment, 2004), new standards for odour emissions from livestock facilities were selected as an area that required research. The new standards for odour emissions will form part of a new odour guide from the Danish Ministry of the Environment.

Odour emissions from different categories of pig facilities have been measured in other countries (Mol and Ogink, 2002; Hayes et al., 2005; Gay et al., 2003; Lim et al., 2001; Zhu et al., 2000; Verdoes and Ogink, 1997), but not in Denmark.

The main aim of the present study was to determine the average odour emission from the most common pig facilities in Denmark during the summer in order to find new standards for odour emissions. The summer period was selected as odour emissions from finishing pigs was found to be highest during this period and is of great concern during public administration in the regulation of air pollutants. Secondarily, the ammonia emissions from the pig facilities were determined at each odour sample. However, only the odour emissions found in this study are used for new regulation in Denmark.

Methods

The nine most common categories of pig facilities in Denmark were selected for this project. Each category was represented by four intensive pig units, which all were mechanically ventilated. The nine categories were:

- Dry sows kept in individual crates with partially slatted floor
- Dry sows kept loose
- Lactating sows kept in individual crates with partially slatted floor
- Lactating sows kept in individual crates with fully slatted floor
- Weaners kept in pens with partially slatted floor
- Weaners kept in pens with fully slatted floor
- Finishers kept in pens with partially slatted floor
- Finishers kept in pens with drained floor
- Finishers kept in pens with fully slatted floor.

Olfactometric odour samples were collected in each unit on three days with two samples per day. Samples were collected from the exhaust ventilation air in Tedlar® bags containing 30 L in compliance with European olfactometric standard EN:13725 (CEN, 2003). On each sampling day, the Tedlar® bags were filled with 0.7 L per minute between 12.00 and 1.00 pm for the first sample and after 1.30 pm for the second sample. A total of 216 olfactometric odour samples were collected in the summer period from June to October. Odour concentration was determined by an accredited olfactometric laboratory according to European olfactometric standard EN:13725 (CEN, 2003). For calculation of the odour emission, the ventilation rate in the pig facility for each odour sample was determined with a Fancom measuring fan (FarmTech a/s, Herlufmagle, Denmark).

To determine the average odour emission from a livestock facility in the summer, the outside temperature was preferred to be averagely 20 ºC at sampling time to ensure maximum ventilation in the facilities. Typically, piglets are weaned at four to five weeks of age and therefore emissions of odour were measured 14 days after farrowing. The odour emission from weaners was measured at 19 kg since they are normally housed in the weaner facility from 7 to 30 kg. Finishers weighed averagely 65 kg when odour measurements took place. For dry sows, the production is continuously and therefore odour measurements were not planned for specific stages in the production period. At each sample day the numbers of pigs were counted and the average weight were estimated from weight at insertion, date of insertion and average daily gain.

In connection with each odour sample, the ammonia concentration was measured in the exhaust ventilation air by Kitagawa Gas Detector Tubes 105SD (Mikrolab, Aarhus, Denmark).

Data Analysis

Odour emission per animal was calculated as:

$$OU_E/s \text{ per animal} = \left(\frac{L \times Q}{W \times 3600} \right),$$

where L is the odour concentration, OU_E/m^3; Q is the ventilation rate, m^3/h; and W is the total number of pigs in facility, no.

The ammonia emission was estimated by using the equation:

$$g\ NH_3\text{-}N/d \text{ per animal} = \left(\frac{M \times V \times Q \times 24}{R \times T \times 1000 \times W} \right),$$

where M is the mol weight of N, g/mol; V is the volume, ppm = ml/m^3; Q is the ventilation rate, m^3/h; R is the gas constant, 0,0821 Lxatm/molxK; T is the temperature in Kelvin, K; and W is the number of pigs in facility, no.

The ammonia emissions and the logarithm transformed odour emissions were processed with an analysis of variance in the MIXED Procedure in SAS (SAS Inst. Inc., Cary, NC).

Results and Discussion

The average odour emissions per animal from the different pig facilities are presented in Table 1. In facilities for dry sows, no statistical difference was found in odour emission depending on whether sows were housed in individual crates or kept loose. However, in facilities for lactating sows, a tendency to lower odour emission was found, if farrowing crates had partially slatted floor compared with farrowing crates with fully slatted floor (P=0.08). The odour emission per animal from lactating sows in farrowing crates with partially slatted floor was 28 per cent lower compared with lactating sows in farrowing crates with fully slatted floor. For weaners, no statistical difference was found in odour emission depending on type of facility. Correspondingly, facilities for finishers did not reveal any difference in odour emission regardless of whether the pens had drained floor or fully slatted floor. However, a tendency to lower odour emission was found for finishers kept in pens with partially slatted floor compared with pens with fully slatted floor or drained floor, respectively (P=0.09). The odour emission from finishers kept in pens with partially slatted floor was 34 per cent lower compared with facilities for finishers with drained floor or fully slatted floor in pens.

Table 1. Odour emissions from different categories of pig facilities. The odour emissions are stated per animal and 5 per cent and 95 per cent quantiles are shown in brackets.

Category of pig facility	Number of observations	Odour emission, $OU_E\ s^{-1}\ animal^{-1}$ (5 per cent & 95 per cent quantiles)
Dry sows – Kept in individual crates or kept loose	48	16 (7 – 39)
Lactating sows – Kept in crates with partially slatted floor	24	72 (40 – 125)
Lactating sows – Kept in crates with fully slatted floor	24	100 (56 – 280)
Weaners – Kept in pens with partially slatted floor or fully slatted floor	48	7 (4 – 14)
Finishers – Kept in pens with partially slatted floor	24	19 (8 – 48)
Finishers – Kept in pens with drained or fully slatted floor	48	29 (13 – 78)

The connection between the observed odour emissions in the summer from different categories of pig facilities and an entire integrated production unit is illustrated in Figure 1. A unit that has a production capacity of 100 livestock units (approximately 100 sows plus finishers) where the farrowing crates for lactating sows have fully slatted floor and the pens for finishers have drained or fully slatted floor, the total odour emission will be 22.900 OU_E/second. However, if both the farrowing crates for lactating sows and the pens for finishers have partially slatted floor, the total odour emission will be reduced by 28 per cent, which corresponds to 16.600 OU_E/second. The figure illustrates that facilities for finishers account for more than 2/3 of the entire odour emission of an integrated production unit.

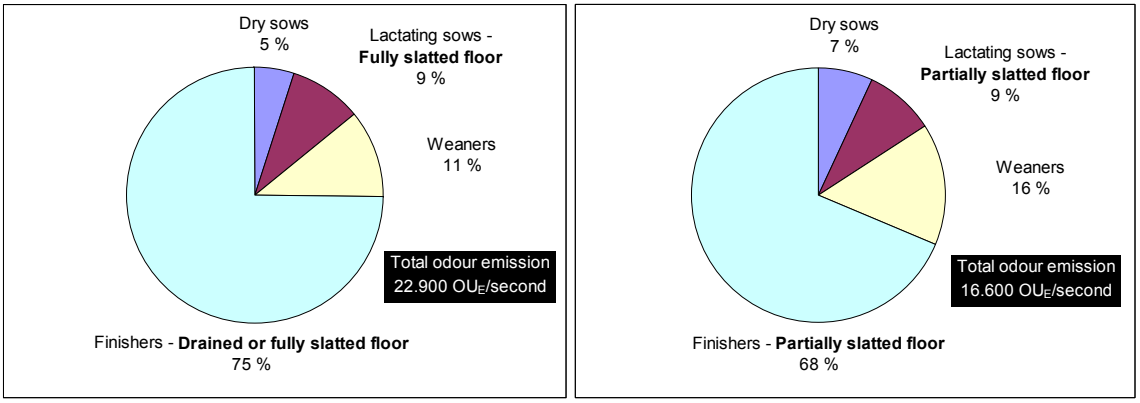

Figure 1. The figure to the left illustrates the distribution of odour emission in the summer from an integrated production unit with a capacity of 100 livestock units (approximately 100 sows plus finishers) where farrowing crates for lactating sows have fully slatted floor and pens for finishers consist of drained or fully slatted floor. The figure to the right illustrates the same distribution, but where both farrowing crates for lactating sows and pens for finishers have partially slatted floor.

The ammonia emissions from different categories of pig facilities are illustrated in Figure 2. No statistical difference was found in ammonia emission from dry sows regardless of whether they were housed in individual crates or kept loose. Correspondingly, no difference was found in ammonia emission from finishers regardless of whether the pens had drained floor or fully slatted floor. However, the ammonia emission was significantly lower from lactating sows in farrowing crates with partially slatted floor compared with crates with fully slatted floor (P=0.01). Also a significantly lower ammonia emission was found from weaners in pens with partially slatted floor compared with pens with fully slatted floor (P=0.04). In addition, the ammonia emission of finishers in pens with partially slatted floor was lower compared with pens with drained or fully slatted floor (P=0.04). Generally, the ammonia emission was higher per animal from dry and lactating sows compared with weaners and finishers.

Conclusions

In conclusion, the type of facility has a great impact on both odour and ammonia emissions from pig facilities in the summer. The odour emission per animal from lactating sows in farrowing crates with partially slatted floor was 28 per cent lower compared with the odour emission from lactating sows in farrowing crates with fully slatted floor. The odour emission per animal from finishers kept in pens with partially slatted floor was 34 per cent lower compared with facilities for finishers with drained or fully slatted floor in pens. Overall, the results illustrates that facilities for finishers account for more than 2/3 of the entire odour emission of an integrated production unit.

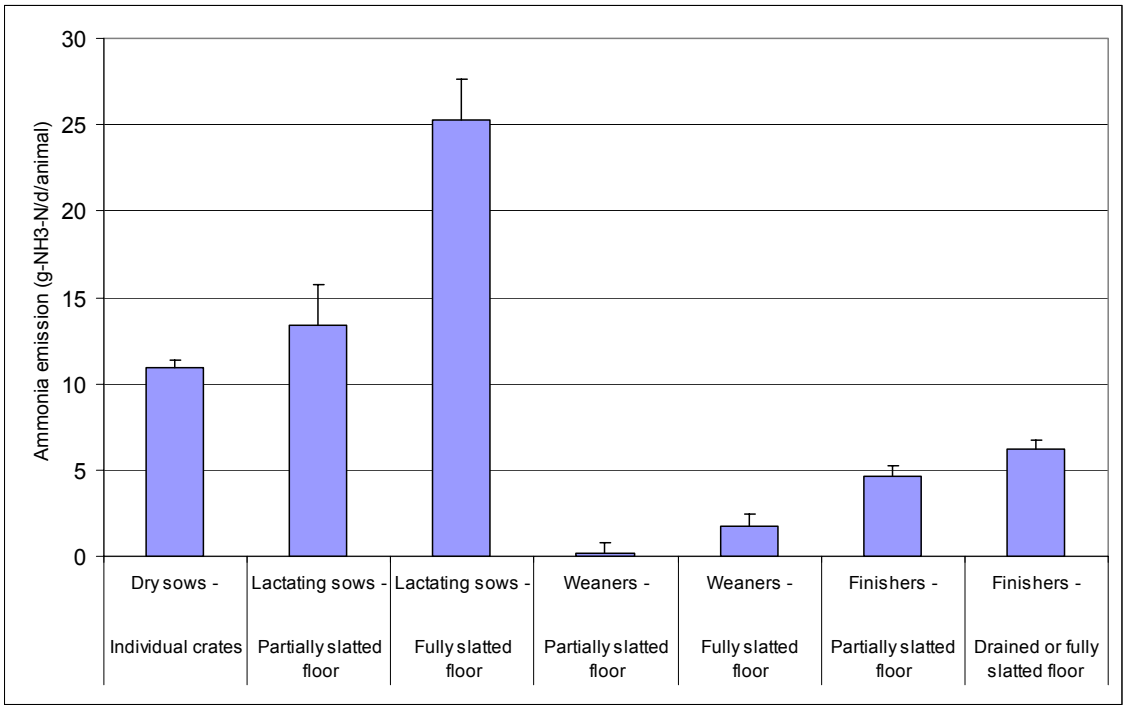

Figure 2. Ammonia emission from different categories of pig facilities measured at each odour sample in the summer period (June to October).

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