

DRAINING OF SLURRY PITS - A SIMPLE WAY TO REDUCE EMISSIONS FROM PIG HOUSING UNITS

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ABSTRACT

Odor nuisance can be a significant problem for neighbors to large pig housing facilities and can have financial consequences for both the neighbors and the pig producers. Draining the slurry pit more often than normal may provide a simple and cost effective method to achieve significant reductions in odor emissions from pig housing units.

Emissions of odor, ammonia, and hydrogen sulfide were measured over a six-month period in two identical sections, each housing 136 finishers. In one of the sections, the slurry was drained weekly, the other section followed typical Danish manure management practices whereby the slurry was removed twice during each production batch of finishers.

The emissions of odor and hydrogen sulfide were reduced by nearly 50 % on the day after draining, but there was no effect on the ammonia emission.

In Denmark, slurry pits in finisher units typically have a depth of 40 cm, with a slurry production capacity of 6-10 weeks, depending on the kind of flooring used in the pens and the time of year.

KEYWORDS.

Ammonia, Odor, Emission, Pig Slurry, Slurry pits,

INTRODUCTION

It is evident that most of the odor from pig production units originates from the slurry and primarily from the pits (Lyngbye and Riis, 2005, in Danish). Studies have shown that ammonia and hydrogen sulfide emissions decrease with the frequency of removing slurry from the pits (Lim et al., 2004), and experience from working with odor reduction of pig slurry indicates that frequent draining of the slurry pits can have the same effect on odor emissions as using odor-reduced slurry in the pits (Lyngbye et al., 2008).

In this study, the objective was to investigate whether weekly draining of the pits in a Danish pig unit could reduce emissions of odor and ammonia compared with typical Danish manure management practices whereby the slurry is removed twice in each production batch of finishers. In the US, pits are often used for storing slurry for several months, so the potential in reducing emissions from units with deep pits should be even higher than in Denmark.

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METHODS AND MATERIALS

The study was performed in two identical sections of a finisher unit with 136 finishers equally divided into eight pens measuring 2.4 m x 4.8 m in each section. The sections were equipped with mechanical ventilation with air intake via a diffuse ceiling and one exhaust per section. Two pens shared a simple dry feeder, and each pen was equipped with a nipple drinker. Feed was supplied *ad libitum*. The pens had fully slatted concrete flooring with 40 cm deep slurry pits below; four pens were drained through a shared pit. The ventilation rate was controlled by the room temperature, which was attempted to be maintained at 18°C.

The study involved two batches of finishers in each of the two sections. The ideal set-up would have been to change groups in the sections between the batches; however, to investigate the long-term effect of weekly draining of the pits on possible sedimentation of solid matter in the pits, it was chosen to continue the weekly draining in the same section for both batches of finishers. Weekly draining of the pits began 2 weeks after placing the pigs in the section at a weight of 35 kg and continued until delivery to the slaughterhouse started at approximately 105 kg. The odor, ammonia, hydrogen sulfide, ventilation rate, temperature and amount of slurry were measured during a period of two batches of finishers.

Slurry

In one of the sections, the slurry was drained once a week, and, in the other section, the slurry was drained once during the production period and once after delivery of the finishers. In the first batch, the pigs were placed in the sections on June 2, and all pits contained approximately 5 cm of slurry. Weekly draining of the pits in the experimental section started on June 22 and continued until August 17. The pits in the control section were drained on June 30 and at the end of the production batch. In the second batch of finishers, the pigs were placed in the sections on September 14, all pits were drained on September 17, and the pits in the experimental section were drained on a weekly basis until November 16. There was no extra draining in the control section before the pigs were delivered to the slaughterhouse.

On each day of odor measurements, the slurry depth was measured manually at four points in each pit (once in each pen), and a mean value from each section was recorded.

Odor

Samples for olfactometric measurements were taken below the ventilation duct in each section the day after the pits had been drained. In total, 13 days with olfactometric measurements were included in the two batches. On each measurement day, two odor samples were taken in each section; one sample was taken between 11 a.m. and 12 p.m., and the other sample was taken between 1 p.m. and 2 p.m. The odor samples were collected in 30-liter Nalophane bags through a Teflon tube. The bags were flushed once before the sampling started in order to condition the surface in the bags with odorants. The sampling time was 30 minutes, and the sampling equipment was located outside the sections to ensure that the technicians did not disturb the behavior of the pigs. The following day, the samples were analyzed at the Danish Meat Research Institute using an Ecoma T08 olfactometer to determine the odor concentration using dynamic olfactometry in accordance with the European CEN-standard (CEN, 2003).

Ammonia and carbon dioxide

The ammonia and carbon dioxide concentrations were measured online once an hour using the Danish VengSystem. This equipment consisted of pumps that delivered approximately two liters of air per minute from the air inlet (used for background levels) and from the air exhausts through Teflon tubes to instruments that analyzed the ammonia and carbon dioxide content in the air. A Polytron 1 from Dräger was used to measure the ammonia concentration, and a Vaisala instrument was used to measure the carbon dioxide concentration. A manifold placed immediately before the two instruments ensured that the air from each source was sent separately to the instruments. The air was analyzed for a period of ten minutes, and only the last recorded value was stored, so the system recorded a new value in each section every other hour.

Before being pumped into the instruments, all the air was preheated to 34°C to avoid condensation of water droplets, and the inlet air was analyzed during every second measurement period. This was done to stabilize the ammonia instrument. Otherwise, it would not have been possible to use the Polytron 1 from Dräger.

Immediately after the olfactometric sampling had been completed, the ammonia and carbon dioxide concentrations were measured using detector tubes from Kitagawa (No.105SD for ammonia and No.126SF for carbon dioxide). This made it possible to check and calibrate the data from the VengSystem.

Hydrogen sulfide

The hydrogen sulfide concentrations in the exhaust air in each section were measured immediately after the olfactometric sampling had been completed. The hydrogen sulfide concentrations were measured using a Jerome 631-XE Analyzer from Arizona Instrument LLC.

Ventilation rate and temperature

The ventilation rate was measured using measurement fans (Fancom, the Netherlands), and the room temperature was measured using VE10 temperature sensors (VengSystem, Denmark) placed immediately below the ventilation duct. Both were measured and stored electronically at 5 minute intervals using software from VengSystem, Denmark.

Calculations and statistical analyses

Emissions of ammonia and hydrogen sulfide were determined by multiplying the concentrations by the ventilation rate. The experimental setup was a case-control study, and the emissions were analyzed statistically using a variance analysis in SAS (SAS, 2009). The odor emissions were log-transformed before the variance analysis was performed. The group and batch were included as systematic effects. For each batch, means and standard deviations were determined for temperature in the ventilation duct, the ventilation rate, and concentrations of ammonia and carbon dioxide.

RESULTS AND DISCUSSION

The weekly draining of slurry pits began in June 2009 and continued during two batches of finishers until November 2009. Figure 1 shows the average slurry depth in the pit in the control and experimental sections. The average slurry depth in the experimental section was 5-6 cm on the day after draining. In the control section, the slurry depth was at the same level when starting the experiment and was above 30 cm at the end of the production periods.

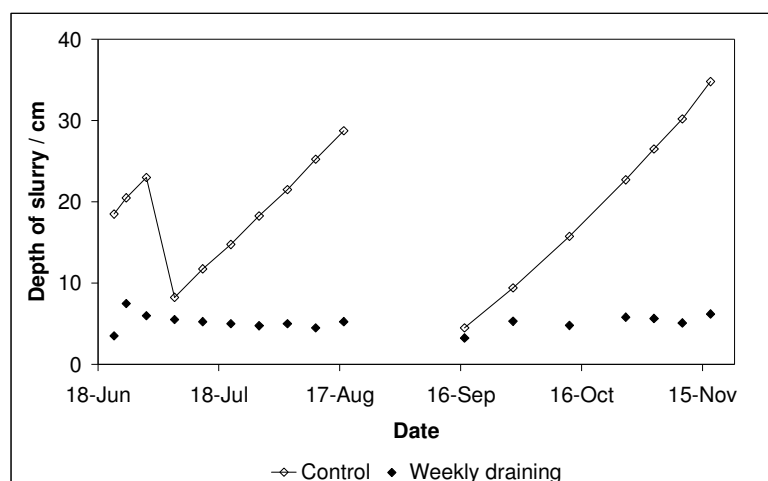


Figure 1. The average slurry depth in the two sections with finishers. Control is the section using typical Danish manure management practices whereby the pits are drained once or twice during a production period from 35 to 105 kg. The pits in the other section were drained once a week.

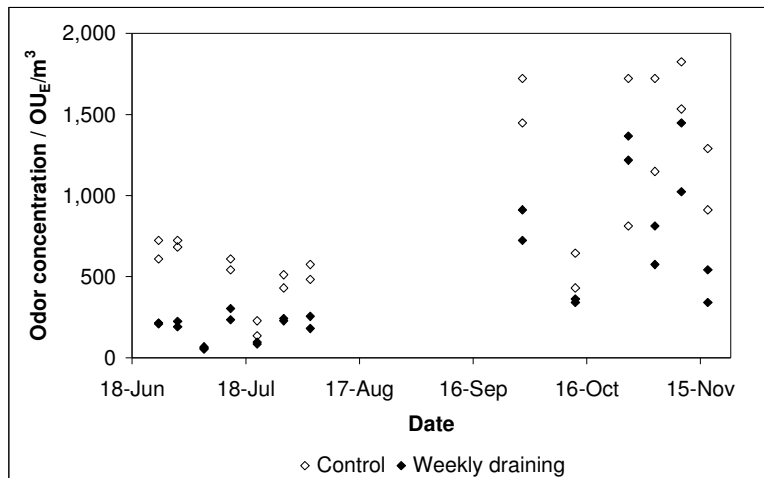


Figure 2. Odor concentration in the exhaust air from the two sections with and without weekly draining of the slurry pits

Odor

The odor concentrations were recorded on 13 measurement days during the two batch periods. All individual measurements are shown in Fig. 2. On every measurement day, there was a lower odor concentration in the section with weekly draining of the pits compared with the control section. One exception is on July 7, when the pits in the control section were newly drained. In this case, there was no difference between the two sections. The odor emissions, calculated using ventilation rates, numbers of animals in the sections and average animal weight on each measurement day, are shown in Table 1.

A statistically lower odor emission was measured in the finisher section where the slurry pits were drained on a weekly basis. The odor emission was 170 $OU_E/sec.$ per 1,000 kg of animal from the control section and was 87 $OU_E/sec.$ per 1,000 kg of animal from the section with weekly draining of the pits, corresponding to a reduction of approximately 50 %.

Table 1. Odor concentrations and emissions from two sections in a finisher unit with and without weekly draining of the slurry pits. The measured values must be compared within the individual batches. The confidence interval (95 %) is shown in brackets.

Batch	1		2		1+2	
Group	Control	Weekly draining	Control	Weekly draining	Control	Weekly draining
Number of measurements	14	14	12	12	26	26
Odor concentration (OU_E/m^3)	350 (210-590)	160 (99-270)	1,170 (680-2,010)	720 (410-1,240)	650 (450-940)	340 (230-490)
Odor emission ($OU_E/sec.$ per 1,000 kg of animal)	120 (72-200)	59 (35-98)	230 (130-400)	130 (74-220)	170 (120-240)	87 (60-130)

Ammonia

Table 2 shows the ammonia concentrations and emissions from the two sections together with the other data recorded electronically using the equipment from VengSystem.

The ventilation rates and the temperatures were slightly higher in the section with weekly draining of the pits compared with the control section. This is true for both batches and resulted in a lower carbon dioxide concentration in the experimental section. Even though there were small differences between the ventilation rates and the temperatures in the two sections, it is still possible to compare data from the two sections.

Table 2. Temperatures, ventilation rates, carbon dioxide and ammonia concentrations, and ammonia emissions from two sections in a finisher unit with and without weekly draining of the slurry pits. The measured values must be compared within the individual batches. The confidence interval (95 %) is shown in brackets.

Batch	1		2		1+2	
Days of measurements	58		51		109	
Outdoor temperature (°C)	18.8 (18.3-19.4)		7.5 (6.9-8.3)		-	
Group	Control	Weekly draining	Control	Weekly draining	Control	Weekly draining
Temperature in exhaust air (°C)	22.4 (22.1-22.7)	22.9 (22.6-23.2)	17.0 (16.8-17.3)	17.5 (17.3-17.6)	-	-
Ventilation rate per animal (m ³ /hour)	89 (87-90)	92 (89-94)	46 (42-49)	49 (46-53)	-	-
Carbon dioxide concentration (ppm)	985 (969-1,000)	930 (913-947)	1,490 (1,400-1,570)	1,440 (1,360-1,520)	-	-
Ammonia concentration (ppm)	14.5 (14.3-14.8)	13.3 (13.0-13.5)	20.7 (20.4-21.0)	19.5 (19.2-19.8)	17.6 (17.4-17.8)	16.4 (16.2-16.6)
Ammonia emission (g NH ₃ -N/hour per animal)	0.70 (0.67-0.72)	0.64 (0.62-0.67)	0.48 (0.45-0.51)	0.52 (0.49-0.55)	0.59 (0.57-0.61)	0.58 (0.56-0.60)

Figure 3 shows the daily average ammonia concentration in the two sections for both batches of finishers. There is a slightly lower, but statistically significant, ammonia concentration in the section with weekly draining of the pits compared with the control section (Table 2). However, since the ventilation rates were slightly higher in the section with weekly draining than in the other section, there was no statistically significant difference between the ammonia emissions from the two sections.

The reason that there was no effect on ammonia emissions could be that, even though the pits were drained on a weekly basis, they were never totally empty, so the surface area of the slurry in the pits in the two sections was the same. Since slurry is the main source of ammonia in the air in the pig units, it seems that the surface area of the slurry has a greater impact on the volatilization of ammonia than the depth or age of the slurry.

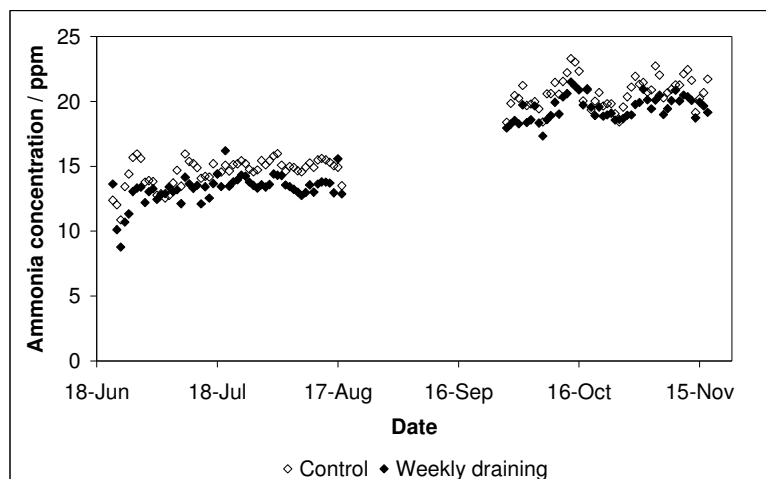


Figure 3. The daily average ammonia concentrations in the exhaust air from the two sections with and without weekly draining of the slurry pits

Hydrogen sulfide

Figure 4 illustrates the individually measured concentrations of hydrogen sulfide in the two sections with finishers. The average concentrations and emissions are shown in Table 3.

Both the concentrations in the exhaust air and the emissions were statistically significantly lower from the section with weekly draining of the slurry pits. Hydrogen sulfide is produced in the slurry

under anaerobic conditions, and it was therefore expected that the concentration in the control section without weekly draining of the pits would be highest, since the slurry in this section remained undisturbed for several weeks and therefore retained its anaerobic layer.

Table 3. Hydrogen sulfide concentrations and emissions from two sections in a finisher unit with and without weekly draining of the slurry pits. The measured values must be compared within the individual batches. The confidence interval (95 %) is shown in brackets.

Batch	1		2		1+2	
Group	Control	Weekly draining	Control	Weekly draining	Control	Weekly draining
Number of measurements	16	16	12	12	28	28
Hydrogen sulfide concentration (ppb)	93 (71-115)	53 (31-75)	83 (57-110)	45 (18-71)	88 (71-105)	48 (31-66)
Hydrogen sulfide emission (mg H ₂ S/hour per animal)	10 (7.6-13)	6.4 (3.9-8.8)	5.7 (3.0-8.4)	2.9 (0.24-5.6)	7.9 (6.1-9.8)	4.6 (2.8-6.4)

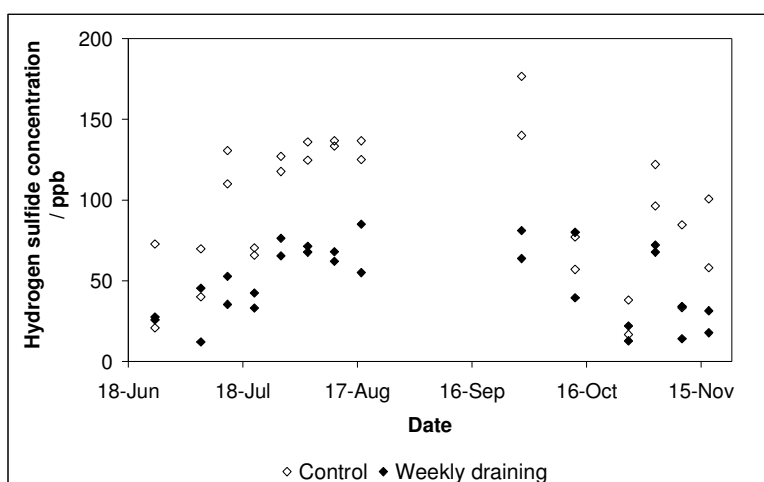


Figure 4. Hydrogen sulfide concentrations in the exhaust air from the two sections with and without weekly draining of the slurry pits

CONCLUSION

Measurements in connection with weekly draining of slurry pits compared with typical Danish manure management practices show that it is possible to achieve statistically significant reductions in odor emissions from pig housing units.

In this study, the odor emission from a section with 136 finishers was reduced by approximately 50 % from 170 OUE/sec. per 1,000 kg of animal from the control section to 87 OUE/sec. per 1,000 kg of animal from the experimental section measured on the day after draining of the pits. A similar effect was observed on the emission of hydrogen sulfide.

The weekly draining of the slurry pits had no effect on the ammonia emission.

Based on the possible effect on reduction of odor and hydrogen sulfide emissions, studies on whether the effect of the weekly draining of the slurry pits were kept for one week until next draining of the pits is currently being carried out. Additional studies with multiple periods for draining (weekly, bi-weekly and tri-weekly) of the slurry pits will be carried out in the summer and autumn 2010 to quantify the optimum period of draining on reduction of odor emission.

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