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AMMONIA AND GREENHOUSE GAS EMISSIONS IN PIG FATTENING ON SLATTED FLOOR WITH EXCREMENT DISCHARGE BY FLAT SCRAPING

Lagadec, S.¹, Landrain, B.¹, Landrain, P.¹., Robin, P.²., Hassouna, M.²

¹ Chambre régionale d'agriculture de Bretagne, France;

² INRA, AgroCampus, France.

ABSTRACT: Gas emissions (NH₃ GHG) from four pig fattening rooms on slatted flooring with flat scraping and under-floor air evacuation were measured in three consecutive batches between May 2009 and June 2010 in the experimental station of Crecom (France). Gas concentrations and ventilation rates were measured and recorded during 3 periods of 14 days during the breeding period (day 7 to 21, 35 to 49 and 63 to 77). Gas concentrations were measured with an infrared photoacoustic monitor (INNOVA 1412) in the room area. Manure was scraped once a day and stored in the breeding rooms for two weeks. Measured carbon emissions (C-CH₄ and C-CO₂) were validated by comparison with the C mass balance deficit, whereas measured nitrogen emissions (N-NH₃ and N-N₂O) were not validated by comparison with the N mass balance deficit. Observed differences between measurement and mass balance deficits were explained by the sampling point site for concentration measurements that was not representative of the exhaust air. With additional experiments, we demonstrated that ammonia concentrations measured in the exhausted air were 51 % higher than those measured in the room. Under-floor air evacuation combined with a flat scraper system enabled the reduction of ammonia concentrations in the room and improved air quality and the working environment. However, compared to a slurry storage system, a flat scraper system with manure stored in the room after scraping, reduces GHG emissions (N₂O and CH₄) in the exhaust air, but can increase NH₃ emissions.

Keywords: GHG, NH₃, pig, emissions, flat scraper

INTRODUCTION: In France, concrete slatted floor is used in 95% of fattening pig houses. With this type of floor, either slurry is stored in a pit under the slats for the duration of the entire fattening period or slurry is frequently removed. According to bibliography, the use of a frequent slurry removal system has several advantages compared to a stored slurry system. This system enables limiting gas and odour formation by reducing the duration time that manure is stored inside the buildings (Guinand, 2000) and improves animal performance (Landrain et al. 2010). Among the different frequent manure removal systems, the flat scraper system is a mechanical system. It consists of a shallow slurry pit with a horizontal steel scraper under the slatted floor, allowing the manure to be removed from the building several times a day (Groenestein, 1994). This system was established in four fattening pig rooms in the experimental station of Crecom (France) and ammonia and GHG emissions were studied in three batches.

1. MATERIAL AND METHODS:

1.1. Animal and experimental design: Three successive batches of pigs from May 2009 to June 2010 were fattened in four identical pig fattening rooms equipped with a flat scraper system in the experimental station of Crecom (France). In each room, 88

pigs were group housed in 8 pens. In two rooms (A and B), pigs were offered liquid food with three meals per day at 6 am, 12 pm and 5.30 pm (restricted ration). Each meal has a dilution rate of 2.2 liters of water per kg of food. In the two other rooms (C and D), pigs were offered dry food on an ad libitum basis (unrestricted ration) and have permanent water accessibility. In the two rooms with the same feeding system, one has an animal density of 1 m² per pig and the other an animal density of 0.7 m² per pig (Table 1).

Table 1. characteristics of the experimental rooms.

Item	A	B	C	D
Animal density (m ² /pig)	1	0,7	0,7	1
Feeding system	liquid	liquid	dry	dry

Manure was scraped once a day and stored in breeding rooms for two weeks. Fresh air entered via a ceiling of perforated plastic sheeting and air exhaust was an under-floor extraction chimney. Pigs were weighed at the beginning and end of each batch and each measurement period, enabling the measurement of individual average daily gains. Food and water intake were registered for each batch and each measurement period to determine the food conversion ratio.

1.2. Measurements: Gas concentrations (ammoniac, nitrous oxide, methane, carbon dioxide and water) were measured inside and outside the room with an infrared photoacoustic monitor (INNOVA 1412) during the breeding period: day 7 to 21 (period 1), 35 to 49 (period 2) and 63 to 77 (period 3). Gas measurements were made every 12 minutes during the three measurement periods. Gas concentration is expressed as mg/Nm³. The temperature (°C) and hygrometry (%) inside and outside were measured continuously and the air flow rate, expressed as m³/h/porc, was calculated with CO₂ balance. Gas emissions, expressed as g/pig/day, were calculated by dividing cumulated emission for each gas per day and per pig. To validate emission factors, measured carbon emissions (C-CH₄ and C-CO₂) were compared with the C mass balance deficit. Additionally, measured nitrogen emissions (N-NH₃ and N-N₂O) were compared with the N mass balance deficit. The C and N mass balance deficit were calculated according to the following formula:

Mass balance deficit (N or C losses by volatilization) = input (piglet carcass, food consumption) – output (pig carcass, slurry composition) (1)

An analysis of variance (R) was performed to test the effects of period, animal density and feeding system.

2. RESULTS AND DISCUSSION:

2.1. Gas concentrations: The overall average N₂O, NH₃ and CH₄ concentrations were, respectively, 1,25 ± 0,22, 9,05 ± 2,84 and 4,75 ± 1,27 mg/Nm³. There was no effect of animal density and period on gas concentrations. Statistical analysis could not be performed to test the effect of the feeding system due to a technical problem in the monitor for two batches with liquid feeding. However, it seems that NH₃ concentrations were lower with liquid food than with dry food.

Compared to NH₃ concentration measured in the room with a slurry stored system, an under-floor air extraction was 13,45 mg/m³ (Guingand, 2000), indicating the flat scraper enables a 32% reduction of the NH₃ concentration in the room.

2.3. Gas emissions: Carbon emissions (C-CH₄ and C-CO₂) explained about 87.5% of carbon losses by volatilization (carbon mass balance deficit), with a 78.3% minimum and a maximum of 102.5%. This means that CH₄ emission factors could be validated. Nitrogen emissions (N-NH₃ and N-N₂O) explained about 47.6% of the nitrogen losses by volatilization (nitrogen mass balance deficit), with a 20.3% minimum and a maximum of 81%. According to these results, NH₃ and N₂O emission factors could not be validated. With additional experiments, we demonstrated that NH₃ concentrations measured in the exhausted air were 51 % higher than those measured in the room (Figure 1), whereas N₂O and CH₄ concentrations were not disturbed by the under-floor ventilation system.

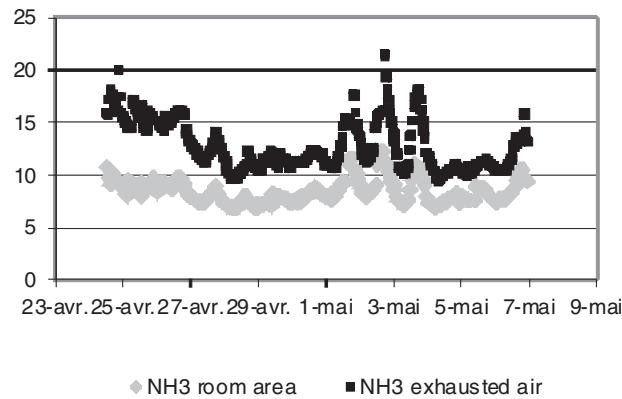


Figure 1. Comparison NH₃ concentrations (mg/Nm³) in the room and in exhausted air.

Observed differences between measurement and mass balance deficits were explained by the sampling point site for concentration measurements that were not representative of the exhaust air. N₂O and CH₄ emission factors were estimated with measurement and NH₃ emission factors were estimated with N mass balance deficit and calculated according to the following formula:

$$\text{NH}_3 \text{ emission (g/pig/day)} = 17/14 \times (\text{N mass balance deficit} - \text{N-N}_2\text{O measured}) / \text{pig/day} \quad (2)$$

Table 2. gas emissions (g/pig/day).

Item		N ₂ O	NH ₃	CH ₄
Measure period	7 to 21 d	0,30 ± 0,08	5,35 ± 0,99	1,74 ± 0,94
	35 to 49 d	0,35 ± 0,13	9,71 ± 2,29	2,61 ± 1,04
	63 to 77 d	0,57 ± 0,35	12,20 ± 2,82	3,85 ± 1,81
	average	0,41 ± 0,24	9,09 ± 3,56	2,73 ± 1,54
	Min	0,17	4,33	1,09
	Max	1,12	15,88	7,69
Feeding system	Liquid	0,43 ± 0,27	9,65 ± 3,71	3,07 ± 1,57
	Dry	0,33 ± 0,07	7,39 ± 2,62	1,71 ± 0,94
Animal density	1 m ² /porc	0,45 ± 0,23	8,63 ± 2,93	2,60 ± 1,26
	0,7 m ² /porc	0,36 ± 0,25	9,55 ± 4,18	2,86 ± 1,82

After validation for the three batches, N₂O emission factors vary between 0.17 and 1.12 g/pig/day and CH₄ emission factors vary between 1.09 and 7.69 g/pig/day (estimated with measurement). NH₃ emission factors vary between 4.33 and 15.88 g/pig/day (estimated with N mass balance deficit). The average N₂O and CH₄ emission factors, respectively, of 0.41 ± 0.24 and 2.73 ± 1.54 g/pig/day were inferior by, respectively, 77% and 72% to the reference emission factors of 1.74g N₂O /pig/day and 9.85g CH₄/pig/day in GES'TIM (Gac et al, 2010). However, an 18% augmentation in comparison with the reference ammonia emission factor (7.68g/pig/day) calculated from the excreted azote given by CORPEN (3.79 kg/pig) and from the percentage of excreted azote under the form of ammonia of 22.5% excreted N . This result is consistent with the bibliography since Philippe et al (2011) found that the frequent dejection evacuation system by flat scraping does not seem to have any positive effect on ammonia emissions. We observe an augmentation of NH₃ and CH₄ emission factors from period 1 to period 3 for each room and each batch. According to the results, dry food engenders a reduction of N₂O, NH₃ and CH₄ emissions in comparison with liquid food. Moreover, a smaller density (0.7 m²/pig) engenders a reduction of N₂O emissions, but promotes augmentation of CH₄ and NH₃ emissions.

CONCLUSION: Compared to a stored slurry system, frequent manure removal with a flat scraper enables improvement of room quality and thus of the workers' and animals' environment with a reduction of ammonia concentration in the air. This system also enables considerable reduction of (more than 70%) GHG (N₂O and CH₄) emissions compared to national reference factors. However, high ammonia volatilization was generated under the slats, which increased NH₃ emissions by 18% with this system compared to a stored slurry system. This result can be explained by storage of the removed manure in the breeding rooms for two weeks, by the small film left on the floor after scraping or by the ventilation system.

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