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Gaseous emissions from weaned pigs raised on different floor systems

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ABSTRACT

Gaseous emissions from agriculture contribute to a number of environmental effects. Carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) are greenhouse gases taking part to the global problem of climate change. Ammonia (NH_3) emissions are responsible of soil acidification and eutrophication and contribute also to indirect emissions of N_2O. This work evaluated the influence of the type of floor on the emissions of these gases in the raising of weaned pigs. Two trials were carried out. In the first trial, the animals were kept either on fully slatted floor or on straw-based deep litter and, in the second one, either on fully slatted floor or on sawdust-based deep litter. For each trial and on each type of floor, 2 successive batches of weaned pigs were raised without changing the litter or emptying the slurry pit between the 2 batches. The rooms were automatically ventilated to maintain a constant ambient temperature.

The performance of the animals was not significantly different according to the floor type. In trial 1, the nitrogen contents of the straw deep litter (including the substrate) and slurry were respectively 276 and 389 g pig^{-1}. In trial 2, the sawdust deep litter and slurry nitrogen contents were respectively 122 and 318 g pig^{-1}.

Raising pigs on straw deep litter produced proportionately around 100% more NH_3 than raising pigs on slatted floor (0.61 g NH_3-N d^{-1} pig^{-1} vs. 0.31 g NH_3-N d^{-1} pig^{-1}; $P < 0.05$). Differences in CO_2, H_2O and CH_4 emissions were not significant between systems. Raising pigs on sawdust deep litter produced also proportionately more NH_3 (+52%; 0.55 g NH_3-N d^{-1} pig^{-1} vs. 0.36 g NH_3-N d^{-1} pig^{-1}; $P < 0.01$) but also more CO_2 (+25%; 427 g d^{-1} pig^{-1} vs. 341 g d^{-1} pig^{-1}; $P < 0.001$) and H_2O (+65%; 981 g d^{-1} pig^{-1} vs. 593 g d^{-1} pig^{-1}; $P < 0.001$) and less CH_4 (−40%; 0.52 g d^{-1} pig^{-1} vs. 0.86 g d^{-1} pig^{-1}; $P < 0.001$) than raising pigs on slatted floor. Practically no N_2O emission was observed from rooms with slatted floor while the N_2O emissions were 0.03 and 0.32 g N_2O-N d^{-1} pig^{-1} for the straw and sawdust deep litter respectively. The warming potential of the greenhouse gases ($N_2O + CH_4$), were about 22, 34 and 168 g CO_2 equivalents per day and per pig on fully slatted floor, straw or sawdust deep litter respectively.

In conclusion, pollutant gas emissions from rearing of weaned pig seem lower with fully slatted plastic floor system than with deep litter systems.

1. Introduction

Agriculture contributes importantly to pollutant gaseous emissions such as ammonia (NH_3), carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) (Monteny et al., 2006; Aneja et al., 2007). These gases have a number of environmental bad effects.

NH_3 contributes to the acidification and eutrophication of soils and waters (Brink et al., 2001) and to indirect emissions of N_2O (Intergovernmental Panel on Climate Change, 2006a). Furthermore, NH_3 is well known as a toxic gas, irritating the respiratory tract at concentrations exceeding 15 ppm (Urbain, 1997). In Europe, approximately 80% of NH_3 production originated from animal production facilities (Brink et al., 2001). According to van der Peet-Schwering et al. (1999), approximately 50% of the ammonia emissions from pig production are from pig housing and slurry storage. The other 50% is emitted during surface application of the slurry.

CO_2, CH_4 and N_2O are the most important greenhouse gases (GHG) associated with livestock production. These gases take part to the global problem of climate change. However, agriculture is also a CO_2-consumer through plant photosynthesis and the contribution of CO_2 to the greenhouse effect is less important than that of CH_4 and N_2O, whose warming potentials over a 100-year period are, respectively, 21 and 310 times that of CO_2 (Intergovernmental Panel on Climate Change, 2007). N_2O also contributes to the destruction of the ozone shield. Approximately

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40% and more than 50% of the anthropogenic emissions of CH_4 and N_2O originate from agriculture. Most important agriculture related CH_4 sources are animals and their excreta (manure), whereas, most of the N_2O is produced in the field (faeces and urine excreted during grazing, nitrogen (N) chemical fertilisers, land applied animal manure) and from animal houses where straw or litter is used (Monteny et al., 2006). The gaseous emissions from livestock houses are thus dependent among others from the housing and floor systems.

The collection of wastes in the form of solid manure with litter presents various environmental advantages compared to liquid slurry such as a reduction in the weight of wastes collected, a decrease in the amount of N in the wastes and a decreased olfactory nuisance (Nicks et al., 2003, 2004). Furthermore, the use of straw has also the asset to improve the pig welfare (Tuyttens, 2005). However, the diminution of the N content of the wastes from litter results in the higher emissions of atmospheric N (N_2), NH_3 and N_2O (Nicks et al., 2003, 2004).

The Kyoto protocol specifies that each complying country should provide adequate methods and instruments to quantify, monitor and verify GHG emissions and their reductions (Monteny et al., 2006). It is thus important to know precisely the emissions associated with different production techniques. However, very few experiments have compared in standardized conditions gaseous emissions of weaned pigs according to floor systems and therefore, few data are available in the literature. The aim of this study was thus to quantify gaseous emissions in the raising of weaned pigs according to the type of floor (fully slatted floor, straw-based deep litter or sawdust-based deep litter).

2. Material and methods

Two trials were carried out successively in experimental rooms located at the Faculty of Veterinary Medicine of Liège University (Belgium). In the first trial, the gaseous emissions were measured with piglets kept either on fully slatted floor or on straw-based deep litter and in the second one, with piglets either on fully slatted floor or on sawdust-based deep litter.

2.1. Animals and feed

For each trial and on each type of floor, 2 successive batches of 40 weaned pigs were raised without changing the litter or emptying the slurry pit between the 2 batches. All the pigs were originated from the same farrowing herd and were divided into 2 homogeneous groups according to the sex and the body weight.

The pigs were fed *ad libitum*. Upon their arrival, they were given a transition feed (baby starter) which after 4 d was gradually replaced by a post-weaning feed (starter). Crude protein, lysine and crude fibre contents measured for the baby starter were 17.5, 1.3 and 3.9% and those for the starter, 17.6, 1.2 and 4.3% respectively. The pigs were weighted individually at the beginning and at the end of the experimental period. The quantities of feed ingested and water consumed were determined per batch.

2.2. Experimental rooms

Two identical rooms with an area of 30 m^2 and a volume of 103 m^3 were arranged to house simultaneously a group of 40 weaned pigs on a fully slatted floor in the first one and on a deep litter in the second one. The slatted floor of plastic panels had a void percentage of 37%. The available floor area for the pigs was 12.2 m^2 (0.31 m^2 pig^{-1}). The slurry pit was 50 cm deep. Before the arrival of the first animals, 600 l water was poured into the pit to have a 5 cm water layer. The available floor space for animals in the room with deep litter was 21.6 m^2 (0.54 m^2 pig^{-1}). Straw deep litter was realized with a 30 cm layer before the arrival of the animals. Thereafter, supplementary quantities of straw were provided depending on the cleanliness of the litter. The total amount of wheat straw was 642 kg (8 kg pig^{-1} on average for the 2 batches). For the sawdust deep litter, 2000 kg of sawdust was used to have a 20 cm layer before the arrivals of the pigs. No supplementary amount was provided thereafter, so the average amount for the 2 batches was 26.7 kg pig^{-1}. The sawdust had a dry matter (DM) content of 65% and was mostly composed of particles with a diameter of 0.2–2.0 mm, which represented 80% of the weight. At the end of each trial, slurry and deep litter were weighed and their DM content and N content, analysed by the Kjeldah method, were determined. About every 10 d, but not during the gaseous concentration measurements, wastes from the pigs raised on sawdust were dispersed over all the area of the pen and incorporated manually, which was not done with the straw-based litter. In addition, to avoid an excessively high concentration of dust in the air, the sawdust-based litter was moistened the 8th and the 13th days after the arrival of the second batch with respectively 24 and 48 l of water.

Each room was ventilated with an exhaust fan and the ventilation rate was adapted automatically to maintain a constant ambient temperature. Fresh air entered through an opening of 0.34 m^2 which was connected to the service corridor of the building; the outside air was thereby preheated before entering the experimental rooms. Moreover, a radiator and 2 heat lamps were placed in each room to obtain the piglets required temperature during the first part of the stay. The air temperatures of the 2 rooms and the corridor were measured automatically every hour. The ventilation rates were measured continuously and the hourly means were recorded with an Exavent apparatus (Fancom®) with accuracy as specified by the manufacturer, of 35 m^3 h^{-1}, i.e. 1% of the maximum ventilation rate of the fan.

2.3. Gas emissions measurement

The concentrations of gases in the 2 experimental rooms and the corridor supplying fresh air were measured with an apparatus from Innova Air Tech Instruments (1312 Photoacoustic Multi-gas Monitor) equipped and calibrated for the measurement of NH_3, N_2O, CH_4, CO_2 and water vapour (H_2O). The air in the experimental rooms was sampled upstream of the exhaust fan and that of the corridor, at 1 m from the air inlet. For each batch, the concentrations were measured 3 times at about 1-week intervals and for 6 consecutive days respectively, i.e. during approximately 45% of the stay. The Multi-gas monitor was programmed by conducting a cycle of 3 measurements every half-hour, once every 10 min, the air being sampled successively in the room with the fully slated floor, the room with the deep litter and the corridor.

The emissions were calculated on an hourly basis taking the hourly concentration as the average of the 2 measurements performed per hour at each location. The emissions were expressed in mg h^{-1} utilizing the following formula: $E = D \times (Ci - Ce)$ with D, the hourly mass flow (kg air h^{-1}); Ci and Ce, the concentrations of gas in the air of the room and corridor respectively (mg kg^{-1} dry air). The mean emissions per day and per pig were calculated for each series of measurements.

2.4. Statistical analyses

Statistical analyses were realized for each trial separately. About performance, initial and final body weights and average daily gains data were collected individually and tested per trial according to the floor system using a general linear model -proc GLM- (SAS, 1999). About gaseous emissions, for each batch and each gas and for the combined data obtained with the 2 batches,