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Ammonia and greenhouse gas emissions from a straw flow system for fattening pigs

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Abstract. The straw flow system is an animal friendly housing system for fattening pigs. The pen is separated into a lying area, where straw is used, and an excretion area. The pigs keep the lying area dry and clean and excrete on slats in the rear of the pen. The system can be operated economically efficient on commercial farms. It was to be investigated, if this animal friendly housing system emitted less NH_3 and GHG than a conventional fully slatted floor system. Emissions of NH_3, N_2O, and CH_4 were measured at a commercial farm for 10 months. Measurements covered all seasons and all stages of fattening. Emissions from the straw flow system were always lower than default values for fully slatted floor systems. © 2006 Elsevier B.V. All rights reserved.

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1. Introduction

Animal welfare and environmental protection are increasingly important. Housing systems must be found that offer animal welfare and emit little NH_3 and greenhouse gases (GHG). Often, a contradiction is seen between animal welfare and environmental protection. Emissions from slurry based pig houses have intensively been researched. Data on emissions from straw based houses are limited. The "Guidance document on control techniques for preventing and abating emissions of ammonia" developed by the UN/ECE "Expert Group on Ammonia Abatement" of the "Executive Body for the Convention on

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Long-Range Transboundary Air Pollution" distinguishes 15 slurry based housing systems for pigs and assigns specific emission factors. Straw based systems are only differentiated in two systems. [4] point to the considerable uncertainty of emission factors and to the very limited data availability.

More research is needed into straw based systems for pigs. Mitigation options for NH_3, and GHG must be proposed. The straw flow system is an animal friendly housing system [1]. It was to be investigated, if it emitted less ammonia and greenhouse gases than a conventional fully slatted floor system.

2. The straw flow system

An animal friendly system for pigs must provide straw or other materials [8]. It is important to renew the material daily or every second day. The normal behaviour of pigs is to separate a lying and an excretion area [6]. Animal friendly systems must thus at least be separated into two functional areas. Pigs spend a considerable part of the day with resting and lying. They prefer non-perforated, soft lying areas.

The Straw-Flow-Welfare-System was developed in Scotland [3]. In 1990, the Federal Research Institute for Agriculture in Alpine Regions/Austria further improved the system and developed the "Straw Flow System Gumpenstein" [1] (Fig. 1). The pen is separated into a lying area and an excretion area. The pigs keep the lying area dry and clean and excrete on elevated slats in the rear of the pen. Pigs are likely to suffer from thermal stress on warm days. To avoid this, sprinklers are installed above the slats of the excretion area.

The concrete lying area has an inclination of 4–10% and is surrounded by opaque walls. Feed is supplied at the front of the pen. All pigs can eat at the same time, which is an important factor for animal welfare. 50–100 g non-chopped straw per pig and day are provided in the rack at the front of the pen. The pigs take the straw from the rack, play with it, chew it and thus transport it slowly to the rear of the pen where it falls in the gut under the slats. With this small amount it is still possible to produce slurry. Work requirement for straw supply is ca. 7 min per produced pig. The straw supply can ideally be used to control the pigs' condition. A straw flow pen offers 1–1.3 m^2 per pig. It can be operated economically efficient on commercial farms [2].

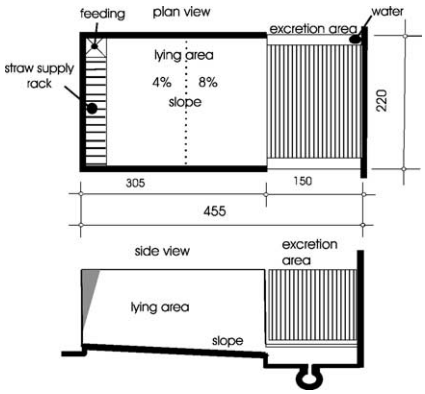

Fig. 1. Design of the straw flow system for fattening pigs (dimensions given in cm; 10–12 pigs per pen).

3. Materials and methods

Emissions of NH_3, N_2O and CH_4 were measured at a commercial farm. The animal house consisted of three fully separated compartments. Each was forced ventilated by a central exhaust fan and was separated into 16 pens that held 10–12 pigs.

Concentrations of NH_3, N_2O and CH_4 were measured with high resolution FTIR spectrometry. Ventilation rate was continuously recorded in the central exhaust fan. Measurements were carried out continuously 24 h a day. The measurement period lasted from 2003-07-01 to 2004-04-20. It covered all seasons: hot–mild–cold, and all stages of fattening. Two contrasting systems for manure removal were investigated: dung channel with manure flow by gravity and daily manure removal via scraper.

4. Results and discussion

Table 1 gives emissions of NH_3, N_2O, CH_4 and GHG per pig place and year. The estimations are based on the following assumptions: a pig corresponds to 0.12 LU (Livestock Units), 1 year covers 2.5 fattening periods [4,7]. Emissions are differentiated in the dung channel system and in the daily manure removal system. Current default values for fully slatted floor systems are given, as well.

Forced ventilated fully slatted floor systems for fattening pigs are estimated to emit 4 kg CH_4 per pig place and year [7]. CH_4 emissions from the straw flow system were considerably lower. A likely reason lies in the reduced amount of slurry that is stored inside the warm animal house compared to a fully slatted floor system with slurry storage underneath the slats. CH_4 emissions are highly temperature dependent and warm temperatures inside the animal house give rise to higher CH_4 emissions.

[4] and [7] give a default emission factor for fully slatted floors of 3 kg NH_3 per pig place and year. NH_3 emissions from the straw flow system were 2.16 (dung channel) and 2.20 (daily manure removal) kg NH_3 per pig place and year. In a straw flow system, only about one-third of the pen is covered with excreta. The pigs keep the lying area dry and clean. This reduces NH_3 emissions from the animal house.

N_2O emissions from a fully slatted floor system are estimated to be about 100 g N_2O per pig place and year. Due to the very limited data on N_2O emissions, this default value comprises a considerable range of uncertainty [7]. From the straw flow system, N_2O emissions of 61.95 (dung channel) and 51.02 (daily manure removal) g N_2O per pig place and year were measured.

Emissions of CH_4 and N_2O were converted to CO_2 equivalents and are expressed as net total greenhouse gas emissions in Table 1. The following global warming potentials

Table 1
CH_4, NH_3, N_2O and net total greenhouse gas emissions from a straw flow system for fattening pigs, and default emissions for fully slatted floors

	CH_4	NH_3	N_2O	GHG
		Emission [kg (pig place*year)$^{-1}$]		[kg CO_2 eq. (pig place*year)$^{-1}$]
Default value	4.00	3.00	100.00	115.0
Dung channel	1.57	2.16	61.95	52.3
Daily manure removal	0.69	2.20	51.02	30.4

(GWP) were used: 21 for CH_4 and 310 for N_2O [5]. Default GHG emissions for fully slatted floors are considerably higher than from the straw flow system. Through daily manure removal, GHG emissions from a straw flow system can further be reduced.

5. Conclusions

The straw flow system for fattening pigs is an animal friendly system that can be operated economically efficient on commercial farms. Emissions of CH_4, NH_3, N_2O and GHG are lower than default values for forced ventilated fully slatted floor systems.

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