Greenhouse Gas Odour Emissions from Pig Production Buildings, Manure Storage and Manure Treatment Facilities

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Introduction

Agriculture as a whole could account for 9.5% of the total Canadian greenhouse gas (GHG) emissions. It is also estimated that 42% of the agricultural GHG emissions originate from livestock operations and one third of these are associated with manure management. There exists a need to better determine the relative contributions of the different stages of livestock production and manure management to the GHG emissions caused by this agricultural sector. Another important emission issue for livestock operations, particularly in swine production, is odours. As for GHG emissions, there is a need to better assess the effects of the different components of livestock operations (animal housing and diet, manure management) on the overall operation emissions.

Objectives

The general objective of this study was to evaluate methane (CH_4), carbon dioxide (CO_2) and nitrous oxide (N_2O) emissions, and also odour emissions for swine operations in two provinces (Québec and Saskatchewan) under liquid manure management. More specifically, the research has been targeted at: 1. determining GHG and odour emissions from different types of swine production buildings and building floor designs; 2. determining GHG and odour emissions from different

types of manure storage facilities, and 3. determining GHG and odour emissions from two manure treatment systems. Greenhouse gas and odour emission results have been expressed in terms of unit animal mass in order to allow for direct comparisons between the different sources. Researchers from four different organizations - the Institut de recherche et développement en agroenvironnement (IRDA), Prairie Swine Centre Inc. (PSCI), Université Laval and the University of Saskatchewan - actively participated in the project.

Table 1. GHG emissions from different room types in two swine production buildings.

Room type	GHG emission (g/day-kg$_{pig}$)			GHG emission – CO_2 equivalence (g CO_2 equivalent/day-kg$_{pig}$)[1]		
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
PSCI Floral site						
Farrowing	49.2	0.63	0.000	49	13	0
Gestation	21.0	0.27	0.000	21	6	0
Nursery	89.0	1.96	0.000	89	41	0
Grower-Finisher	144.5	0.14	0.002	145	3	1
PSC Elstow Research Farm Inc. site						
Farrowing	36.8	0.10	0.000	37	2	0
Gestation	26.9	0.07	0.000	27	1	0
Nursery	30.4	0.39	0.000	30	8	0
Finisher (Partially slatted)	90.5	0.24	0.000	90	5	0
Finisher (Fully slatted)	92.3	0.43	0.001	92	9	0

Experimental Procedures

Greenhouse gas and odour emissions from intensive swine housing gestation, farrowing, nursery and grower-finisher rooms were determined at both the PSC Floral and Elstow sites, with grower-finisher rooms with both partially and fully slatted floors at Elstow. In Saskatchewan, GHG and odour emissions were measured at four dif-

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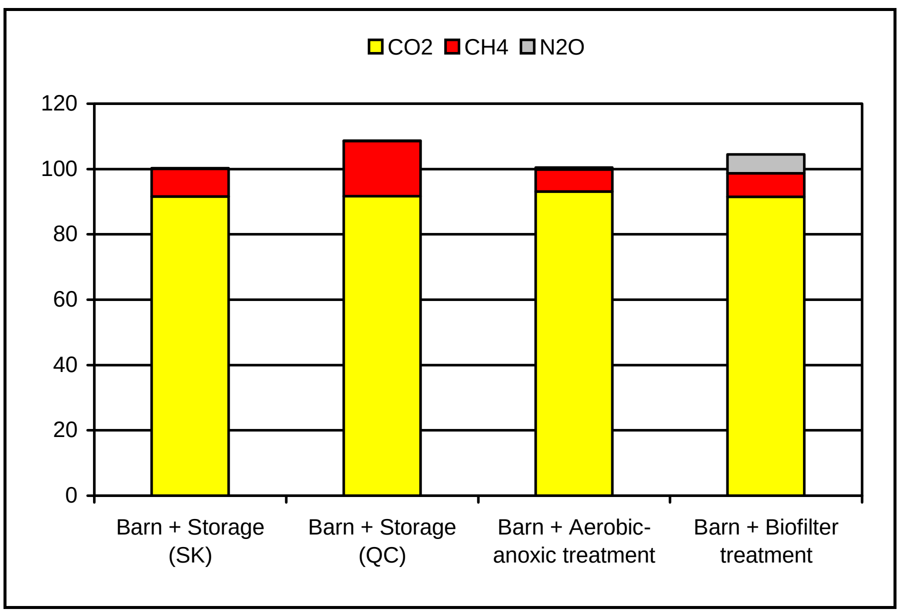
ferent sites that make use of an uncovered concrete tank (1 site), an uncovered 2-cell earthen manure basin (EMB; 1 site) and covered 2-cell EMB (2 sites). Blown chopped straw was used to cover the EMB facilities at those last two sites. One uncovered concrete tank and two manure treatment facilities were monitored in Québec. One of those treatment facilities uses the bio filtration principle and the other one uses alternate periods of aerobic and anoxic phases.

All emission data has been reported in terms of mass (g) of CO_2-equivalent per day per unit animal mass (kg_{pig}). Based on the respective global warming potential (GWP) of the three GHG, the conversion factors are as follows: 1 g of CO_2 = 1 g of CO_2-equivalent; 1 g of CH_4 = 21 g of CO_2-equivalent; 1 g of N_2O = 310 g of CO_2-equivalent.

Results

Figure 1. GHG emissions from different production systems.



Greenhouse gas emissions (all values expressed in g of CO_2-equivalent per day per kg of animal mass)

The most important contributor to GHG emissions from swine buildings was carbon dioxide (Table 1). On an animal mass basis, methane emissions were much lower than CO_2 emissions, and nitrous oxide production was found to be negligible. The lowest CO_2 production was measured in gestation rooms, and the largest was in grower-finisher rooms.

Greenhouse gas emissions from different types of manure storage facilities (i.e. earthen manure storage basins (EMB) uncovered or covered with blown chopped straw; concrete storage tanks) were measured during the 2001, 2002 and 2003 seasons in Saskatchewan. Average (range) GHG emissions from manure storage facilities were as follows: 2.41 (0 to 25.00) for methane; 0.94 (0 to 7.00) for carbon dioxide and, <0.01 for nitrous oxide. Average total GHG emissions from uncovered EMB, covered EMB and uncovered tank storage facilities measured in this study were 4.23, 2.52 and 6.65 respectively. Average total GHG emissions from EMB primary cells measured in this study were 1.90 (uncovered) and 1.41 (covered) while corresponding values for EMB secondary cells were 10.08 and 1.46 respectively. These two series of results confirm the positive impacts of blown chopped straw covers on GHG emissions from manure storage facilities. Average total GHG emissions during the spring, summer and fall seasons respectively amounted to 0.47, 3.91 and 3.49. Finally, average total GHG emissions during the daytime (between 06:00 and 18:00) and night (between 18:00 and 06:00) periods, as measured in this study, were 9.35 and 13.92 respectively.

Greenhouse gas emissions from a concrete tank manure storage facilities were monitored during the 2001, 2002 and 2003 seasons in Québec. Average (and range) GHG emissions were as follows: 10.81 (1 to 40) for methane and 1.03 (0.1 to 4) for carbon dioxide. Nitrous oxide emissions were found to be negligible. Greenhouse gas emissions were not affected by the depth of manure in the storage facility, Similarly, no diurnal/nocturnal effects on GHG emissions could be determined from the experimental results. However, summertime methane and carbon dioxide emissions were respectively ten and five times more important than those observed during the fall.

Greenhouse gas emissions from an aerobic-anoxic manure treatment system were monitored during the 2002 and 2003 seasons. Average GHG emissions were as follows: 0.77 for methane, 2.39 for carbon dioxide and 0.38 for nitrous oxide. No diurnal/ nocturnal or seasonal effects on GHG emissions were detected. However, treatment phases (aerobic or anoxic) did influence GHG emissions. Carbon dioxide emissions were more important during the aerobic phase while nitrous oxide and methane emissions were more important during the anoxic phase. Greenhouse gas emissions from a biofilter manure treatment system were monitored during the 2002 and 2003 seasons. Average (and range) GHG emissions were as follows: 1.05 (0 to 3.59) for methane, 0.87 (0 to 3.35) for carbon dioxide and 5.63 (0.13 to 35.79) for nitrous oxide.

Figure 1 summarizes the total GHG emissions of different productions systems based on the emission results observed in this study. It can be seen that the main contributor is the carbon dioxide emitted from the production buildings. Overall emissions for different types of production systems (i.e. storage or treatment of the manure produced by the animals) are all of the same order of magnitude.

Odour emissions

Nursery pigs at the PSCI Floral site produced the highest odour emission followed by the grower-finisher rooms at the PSC Elstow Research Farm Inc. site. The nursery room at the Floral site is based on an older design where more manure accumulates on the floor compared to the nursery room at the Elstow site. However, the gestation room produced the most important odour emissions.

Odour emissions from three types of manure storage facilities (uncovered and covered EMB, uncovered concrete tank) were measured in Saskatchewan during the 2001, 2002 and 2003 seasons. All experimental data has been expressed in terms of odour units (O. U.) per second per kg of animal mass. Average odour emissions from all types of manure storage facilities during those three seasons were 0.0342 (in 2001), 0.0224 (in 2002) and 0.0362 (in 2003). Average odour emissions from covered EMB, uncovered EMB and uncovered tank storage facilities were respectively 0.0208, 0.0335 and 0.0481. Average odour emissions from EMB primary cells measure`d in this study were 0.0265 (uncovered) and 0.0089 (covered by chopped straw) while corresponding values for EMB secondary cells were 0.0481 and 0.0328 respectively. As for GHG, these two series of results indicate that odour emissions were positively impacted by the presence of a blown chopped straw cover on the surface of the stored manure. Average odour emissions during the spring, summer and fall seasons measured in this study were respectively 0.0369, 0.0276 and 0.0294. Finally, average odour emissions during the daytime period, as measured in this study, were 0.0241 during the morning (07:00 to 10:00), 0.0273 at noon (11:00 to 14:00) and 0.0235 during the afternoon (15:00 to 18:00).

Odour concentrations and intensities were measured over a 2-year period (2002 and 2003) on three swine operations equipped with a conventional pig manure storage tank, an aerobic-anoxic manure treatment system and a biofilter manure treatment system in Québec. The aerobic-anoxic manure treatment system (1.7 OU/s-m^3) emitted fewer odours than the biofilter treatment system (7.3 OU/s-m^3). Odour intensities, in ppb equivalent of 1-butanol, emanating from the site with the aerobic-anoxic treatment system