COMPARISON OF GAS AND ODOUR EMISSIONS FROM SWINE MANURE MANAGEMENT WITH AND WITHOUT TREATMENT FACILITIES IN QUÉBEC

S. Godbout, F. Pelletier, A. Marquis, L.-O. Savard, J.-P. Larouche, S. P. Lemay, R. Joncas, C. Laguë

Research and Development Institute for the Agri-Environment (IRDA), 120-A chemin du Roy, Deschambault, Québec, Canada, G0A 1S0. stephane.godbout@irda.qc.ca

ABSTRACT

Greenhouse gas (GHG) and odour emissions were measured over a two-year period from a swine manure storage tank and from two swine manure treatment facilities (an aerobic-anoxic and a biofilter manure treatment system). Floating open chambers were used to collect air samples on top of the stored manure. GHG concentrations were either measured continuously, during two-week periods at different seasons by gas chromatography or determined from air samples collected using syringes and stored in evacuated glass containers. All GHG emissions data were expressed in terms of mass of CO_2 equivalent to allow direct comparisons and additions of the emissions for the three different GHG. Air bag samples were collected and odour concentrations (in OU m^{-3}) were measured using a dynamic dilution olfactometer. Odour intensities (in ppb equivalent of 1-butanol) were measured on site using a suprathreshold dynamic dilution olfactometer. According to the results obtained in this project, manure treatment systems contributed to reduce GHG and odour emissions.

Keywords: *swine, greenhouse gas, odour, manure storage and treatment.*

INTRODUCTION

Manure management can constitute an important source of gas and odour emissions in livestock production. During the last decade, swine production has increased significantly in the province of Québec. In part because of gas and odour emission issues, social pressures now restrain the expansion of this production. Gas and odour emissions produced by swine operations are influenced by many factors such as building configuration, ventilation, manure management techniques, etc. The objective of this project was to compare GHG and odour emissions for complete manure management system (storage and land application) that either incorporate a manure treatment component or not. During this project, GHG and odour emissions were measured over a two-year period from a swine manure storage tank and from two different swine manure treatment facilities.

MATERIALS AND METHODS

Farm and manure treatment descriptions

Farm #1 - Manure storage tank: The first farm consisted of a grower-finisher building of 940 pig-places under liquid manure management. Usually, 800 pigs were housed in the building and fed with a three-stage dry feed program. The manure was transferred weekly from an inside building storage tank to an outside conventional concrete manure storage tank of 30.5 m in diameter and a depth of 3.7 m.

Farm #2 - Aerobic-Anoxic manure treatment system: The second farm consisted of a farrow-to-wean building housing 90 gestating sows. This farm operation was equipped with an aerobic-anoxic manure treatment system called “Biofertile™”, developed by Envirogain (www.envirogain.com). This treatment began with a screw-press separator. The solid phase was sent to a composting facility and the liquid phase was treated in an aerobic-anoxic bioreactor. Liquid effluents could then be used for irrigation or directly disposed in watercourses or water bodies following an additional treatment. This system was completely enclosed inside the building with only one air outlet.

Farm #3 - Biofilter manure treatment system: The third farm consisted of four nurseries and five grower-finisher buildings. The farm was equipped with a biofilter manure treatment system called “Biosor™” developed by the CRIQ (www.criq.qc.ca). The manure used in the treatment system came from the four nurseries (5,400 piglets) and two grower-finisher buildings (1,600 pigs). The pig manure had a high organic load due to a lactoserum-based feeding. The manure treatment system began with a physico-chemical separation. The solid phase was sent to a composting facility while the liquid phase was treated into two primary biofilters, aerated with the ventilation air of one grower-finisher building, from which it followed into one polishing biofilter. The treated liquids were sent to a soil absorption field.

Greenhouse gas measurements

Floating aluminium chambers were used to collect air samples on top of the manure storage tank. An air pump, solenoid valves, and Teflon® tubes were used to convey the air from the chambers to a gas chromatograph (GC).

Air samplings from the aerobic-anoxic treatment were made directly from the air outlet duct by using gas tight syringes and 10-ml vials. Gas analysis were made with a GC in the laboratory of Agriculture and Agri-Food Canada in Sainte-Foy, Québec.

For the biofilter treatment, the air was sampled at ten points located on biofilter #1 and on the scrubbing biofilter: air inlets, low air outlets and the three upper air outlets of both biofilters. A rotary valve, an air pump and Peek™ tubes were used to convey the air from the ten sampling points to a gas chromatograph.

Odour analyses and sampling methods

For the odour concentration measurement, air samples were taken on site in 40-Litres Tedlar® bags. Odour concentrations were measured using a dynamic dilution olfactometer and expressed in odour units per cubic meter of air (OU m^{-3}). For the manure storage tank, two bags were collected on top of the manure surface. For the aerobic-anoxic treatment, the two bags were collected at the air outlet. For the biofilter treatment, one bag was collected on top of the manure storage tank and the other one was collected on top of biofilter #1.

Odour intensities in ppb equivalent of 1-butanol were measured on site by a suprathreshold dynamic dilution olfactometer. Five or six sampling points, selected in regard of the wind direction (upwind and downwind) and the location of buildings, manure storage and treatment facilities, were taken on each farm.

RESULTS AND DISCUSSION

Greenhouse gas emissions

Figure 1 presents the average daily GHG emissions, manure temperature and depth of manure, in the manure tank, between April 13 and November 10, period inside which the manure temperature was higher than 0°C (emissions were considered negligible when manure temperature was below 0°C). GHG emissions over the missing periods (hatched areas on figure 1) were estimated from a regression equation obtained from measurements made in this project and relating GHG emissions to the manure temperature. Figure 1 shows that emissions from the manure tank increased with temperature and were not influenced by the depth of manure. GHG emissions from manure treatment systems were practically constant.

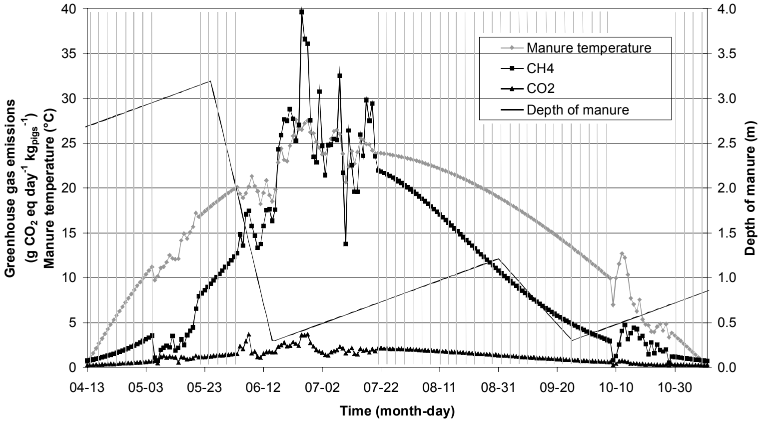

Figure 1. *Average daily greenhouse gas emissions, manure temperature and depth of manure in the tank between April 13 and November 10.*

Table 1 presents the total GHG emission values for the three manure management systems. GHG emissions from land application and composting of the solid phase from treatment systems were assessed using literature data. Results show that treatment facilities emitted less CH_4 and CO_2 but more N_2O than liquid manure storage facilities. According to table 1, manure management on farm #2 and #3 emitted respectively 64% and 33% less GHG than manure management on farm #1.

Table 1. *Greenhouse gas emissions of the three manure management systems.*

Sources	Greenhouse gas emissions (g CO_2 eq $year^{-1}$ kg_{pigs}^{-1})								
	Manure storage tank			Aerobic-Anoxic manure treatment			Biofilter manure treatment		
	CH_4	CO_2	N_2O	CH_4	CO_2	N_2O	CH_4	CO_2	N_2O
Manure tank	2,343	268	0	-	-	-	-	-	-
Treatment system	-	-	-	281	872	139	383	318	2,055
Land application[1]	0	2,555	106	-	-	-	-	-	-
Composting[2 and 3]	-	-	-	26	299	285	18	237	507
Sub-total	2,343	2,823	106	307	1,171	424	401	555	2,562
Total (three gases)	5,272			1,902			3,518		
Total (CH_4+N_2O)	2,449			731			2,963		

[1]*Rochette et al. (2000 a and b);* [2]*IPCC (2001);* [3]*Barrington et al. (2002).*

Odour emissions

Odour emissions, computed with odour concentrations, from the manure tank were around 12 OU s^{-1} m^{-2} or 0.003 OU s^{-1} m^{-3} of manure. Land application of this manure must also be considered as an odour source. A study conducted in The Netherlands by Pain et al. (1991) measured odour emissions from the application of pig manure on grassland with a conventional farm vacuum tanker. During the first hour, results obtained varied from 67.6×10^3 to 360.0×10^3 OU s^{-1} m^{-3} of manure applied. Odour emissions pattern followed the form of an exponential decay curve with initially high rates of emissions followed by much lower rates between 6 and 60 hours after application (Pain et al., 1991). Odour emissions from the aerobic-anoxic and from the biofilter treatment were around 1.5 and 6.7 OU s^{-1} m^{-3} respectively. Odour emissions of both liquid and solid phases after treatment were not measured but, based on preliminary assessments, could be considered very closed to zero.

On farm #1, odour intensities around the building and the manure tank were 9.8 times higher than intensities upwind of the farm. On farm #2, odour intensities around the building and the treatment facility were 2.9 times higher than intensities upwind of the farm. On farm #3, odour intensities around the buildings and around the manure treatment facilities were respectively 7.9 and 24 times higher than intensities measured upwind of the farm.

CONCLUSIONS

Greenhouse gas and odour emissions were measured over a two-year period on three swine farms equipped with a concrete manure tank under liquid manure management, an aerobic-anoxic manure treatment system and a biofilter manure treatment system.

Total GHG emissions (including CO_2) from the farm under liquid manure management (manure tank and land application) were equal to 5.3 kg CO_2 eq year^{-1} $kg_{pigs}{}^{-1}$. From the aerobic-anoxic treatment system and the biofilter treatment system, total GHG emissions (including CO_2) were equal to 1.9 and 3.5 kg CO_2 eq year^{-1} $kg_{pigs}{}^{-1}$, respectively. Compared to liquid manure management, these results represent a reduction of 64% and 33%, respectively. Odour emissions from the manure tank were 12 OU s^{-1} m^{-2}. From the aerobic-anoxic treatment system and the biofilter treatment system, odour emissions were respectively 1.5 OU s^{-1} m^{-3} and 6.7 OU s^{-1} m^{-3}. According to the results obtained, manure treatment systems contributed to reduce GHG and odour emissions.

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