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GREENHOUSE GASES EMISSIONS FROM DEEP PIT STORED SWINE MANURE IN SOUTHERN BRAZIL

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ABSTRACT: Greenhouse gases (GHG) emissions were monitored in an open pit containing swine manure which represents the usual storage structure employed for the management of livestock wastewater in Brazil. Methane (CH_4), carbon dioxide (CO_2) and nitrous oxide (N_2O) were measured in a circular concrete deposit which received daily loads of $1m^3$ of fresh swine manure. GHG assessment was carried out through 50 days during winter using a conical dynamic chamber installed above the pit to cover the whole emitting surface and with a ventilation rate fixed at 147 $m^3.h^{-1}$. Samples from inlet and outlet air were continuously collected and analyzed by infrared photoacoustic gas monitor. Results have shown that methane and carbon dioxide constituted the main GHG emitted from the manure storage. Approximately 82% of mineralized organic carbon was emitted as methane due to the oxygen-limited condition that prevails in this environment. Furthermore the manure temperature measured during the experiment was relatively high (>20^{0}C) which favor the methanogenesis. Additionally, no N_2O emission was observed during the monitored period which confirms the anaerobic character of the biodegradation.

Keywords: methane, carbon dioxide, nitrous oxide, manure pit, livestock, global warming.

INTRODUCTION

Agriculture is known as a major contributor to GHG emissions. CH_4 is produced when organic materials are decomposed under anaerobic conditions, notably from fermentative digestion by ruminant livestock, from stored manures, and from rice grown under flooded conditions (Metz et al., 2007). The main source of GHG emissions from industrial production of poultry and swine are the beddings and the storages of manure, respectively.

Brazil is the fourth largest exporter of swine meat with a production of about 2.9 million Ton/year (Santos Filho & Souza, 2011; ABIPECS, 2011). Currently the adopted management for the manure in almost all Brazilian farms of swine production consists in daily or weekly removal of liquid manure from the channels of the building. Then the wastewater is conducted by pipes to an external deposit (open pits or lagoons) where it is kept during about 120 days for partial stabilization and subsequent land application.

During the manure storage, CH_4 and CO_2 produced by anaerobic degradation of organic matter and also by aerobic bacterial activities at air/slurry interface are emitted to atmosphere (Moller et al., 2004). Although mathematical models have been developed to estimate this emission (IPCC, 2006), most part of data used to generate these models and emissions factors were obtained under temperate climate which could increase the uncertainties about the estimations made for livestock production located in tropical countries. According to Sommer et al. (2007) the production and emission of CH_4 from swine slurry is strongly affected by temperature and there is indeed the need for a better understanding about the relationship between temperature and CH_4 production to improve emission calculation on a global scale. Recent articles have shown that frequent removals of sludge from the channels can significantly mitigate CH_4 emission by: reducing the pool of methanogenic bacteria within this environment, and transferring the sludge to an outside store under lower temperature (Chadwick et al. 2011). Therefore both, temperature as well as manure management can affect the rate of GHG emission.

The aim of this work was measuring the emission flux of CH_4, CO_2 and N_2O in a pilot-scale swine manure pit that reproduce the usual management adopted in Brazilian farms.

MATERIAL AND METHODS

Manure storage and management description:

The experiment was carried out in the City of Concordia, Santa Catarina State, in South of Brazil (27^{0}18'46" S, 51^{0}59'16" W) during 50 days from June 12th to August 1st, 2012. A circular concrete earth pit (internal diameter= 5.02 m; height= 1.8 m; volume=35.6 m^3) was daily fed during 30 days (5 days a week) with aliquots of 1 m^3 of fresh manure from a demo farrow-to-finishing operation with 14-sow. Samples of the added manure were collected at each load and analyzed for pH, dry matter (DM), volatile solids (VS), ammoniacal nitrogen ($N\text{-}NH_3$), total kjeldahl nitrogen (TKN), chemical oxygen demand (COD) and organic carbon (OC) – Table 1, according to official methods (APHA, 1995).

GHG emissions measurement:

A conical dynamic chamber was made with transparent PVC (5.05 m diameter and 1.6 m high with a volume of 10.6 m^3) and installed above the pit (Figure 1) leaving a space of 20 cm between the concrete margin of the pit and the lower edge of the chamber to allow the entrance of fresh air. An exhaust pipe Ø = 300 mm was installed on the top of the chamber and the ventilation rate was fixed at 147 m^3.h^{-1} using a fan equipped with a dimer. The sampling point of outlet air was located in the exhaust pipe 53 cm before the fan, whether the samples of inlet air (fresh air) were collected in two opposite points right below the lower edge of the chamber. Samples were continuously (every 2 minutes for each sampling point) and automatically pumped to the measurement device – Multipoint Sampler and Doser/Infrared Photoacoustic Gas Monitor (INNOVA 1313/INNOVA 1412, Air Tech Instruments, Denmark) – through Teflon tubes of 4 mm in diameter placed in the sampling points.

Greenhouse gas emission flux (g.h^{-1}) was calculated using the equation:

$$E_G = [Q_{air}\,(C_o - C_i)]/1000 \qquad (1)$$

Where: C_o = gas concentration in the outlet air (mg.m^{-3}); C_i = gas concentration in the inlet air (mg.m^{-3}) and Q_{air} = airflow rate (m^3.h^{-1}).

GHG emissions were measured for 50 days, of which the first 40 days corresponded to the loading period when deep pit was fueled with 1 m^3 of fresh manure per day (5 days a week) followed by a period of 10 days without any loading when the system was kept undisturbed.

RESULTS AND DISCUSSION

During the experiment, no N_2O emission was detected from the system. This behavior was already expected since anaerobic biodegradation prevails in pig manure storages and there is little opportunity for NH_4^+ to be nitrified (Chadwick et al., 2011).

Sommer et al. (2007) has demonstrated that the emission proportion CO_2/CH_4 is highly influenced by storage temperature where the methanogenic microbial community dominates the organic material decomposition in temperatures above 20^{0}C (20-65% of C emitted as CH_4 at 20^{0}C). Although our experiment has been conducted during winter, the temperature of manure varied just from 21 until 25^{0}C - Figure 2(c), and the emission fluxes of CH_4 and CO_2 showed in Figures 2(a) and 2(b) agrees with the statement above, as 82.6 ± 3.1% of carbon was emitted as CH_4. The cumulated emissions of CH_4 and CO_2 during the 50 days of monitoring were 4.22 and 0.864 kg of C, respectively.

Considering the two distinct periods (loading and undisturbed) and the available VS content on the pits as manure is being added, the average CH_4 emission during the first period (40 days) was 0.020 ± 0.010 g C.h^{-1}.kg^{-1} SV and then it has dropped to 0.010 ± 0.002 g C.h^{-1}.kg^{-1} SV.

CONCLUSION

Biodegradation of stored manure in open pits in tropical countries are essentially anaerobic even on winter due to the milder drops of temperature in this region which favors methanogenic activity. This behavior can have two consequences related to GHG emission during manure storage comparing to temperate climate region: 1) higher $CH_4/(CH_4+CO_2)$, 2) lower N_2O production. Therefore there is a need for further investigation to evaluate and quantify these two effects, once they are antagonistic, as well as their consequence for the gases emissions in the following stages of manure management such as in its application in crops and pasture.

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Table 1. Chemical characterization of swine manure loads (n= 30).

Varable	Mean	SD	Maximum	Minimum
pH	7.27	0.17	7.64	6.93
DM (%)	2.76	1.15	6.98	0.82
VS ($g.L^{-1}$)	16.0	7.86	19.90	4.37
N-NH_3 ($g.L^{-1}$)	1.84	0.57	3.15	0.81
TKN ($g.L^{-1}$)	2.61	0.89	5.36	1.01
COD ($g.L^{-1}$)	33.0	13.2	63.90	8.35
OD (%)	1.10	0.62	3.47	0.31

Figure 1. Dynamic chamber installed above the manure storage pit to continuous assessment of the emission of CH_4, CO_2 and N_2O.

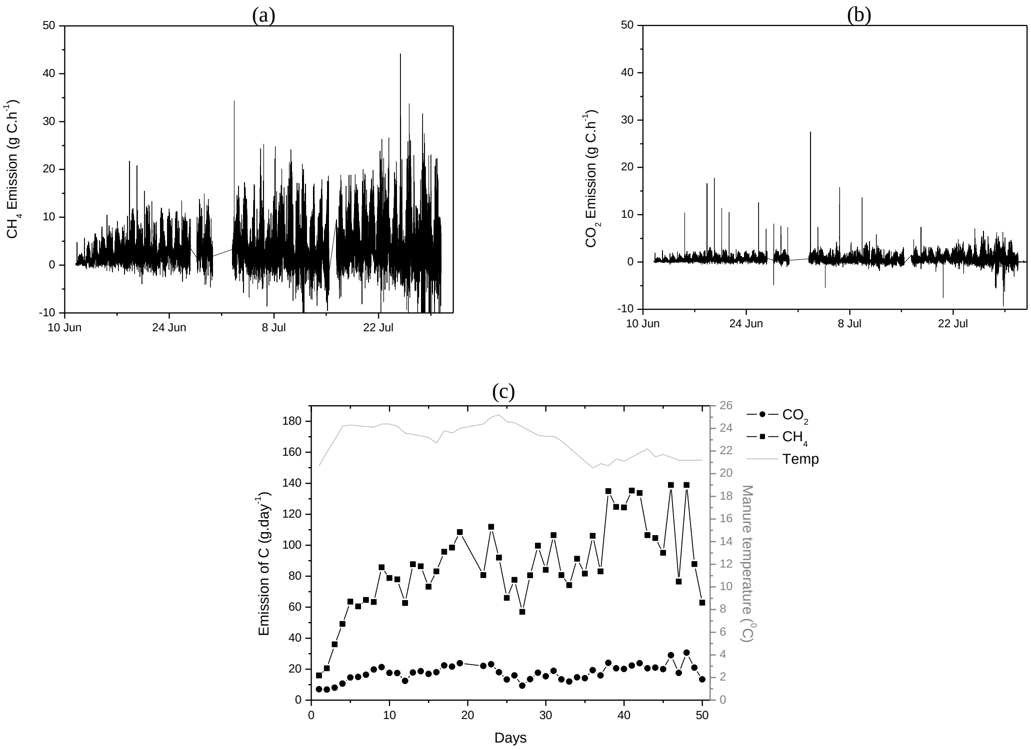

Figure 2. Emission fluxes of CH_4 (a) and CO_2 (b) continuously monitored ($g\ C.h^{-1}$) and daily emission of CH_4 and CO_2 (c).