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GLOBAL WARMING POTENTIAL OF THREE SWINE MANURE MANAGEMENT SYSTEMS USED IN BRAZIL

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ABSTRACT: The experiment was run in triplicate; the greenhouse gases were monitored for 180 days in different manure management systems (composting, raw slurry deposit and open lagoon post-anaerobic digester). Methane (CH_4), carbon dioxide (CO_2) and nitrous oxide (N_2O) emissions rate (g/h) and the accumulated emissions were calculated. The Global Warming Potential (GWP) was estimated from these data. Results has shown that in this study composting had the higher GWP with 200 g eq CO_2 per kg of manure, while raw slurry deposit had 165 g eq CO_2 per kg of manure, and the set (anaerobic digester + open lagoon) had 78 g eq CO_2 per kg of manure. The biggest contributor for composting GWP was N_2O (42,3%), whether the CH_4 accounted for 92,6% and 96,8% of GWP in raw slurry deposit and open lagoon post-anaerobic digester, respectively.

Keywords: composting, greenhouse gas, lagoon, livestock waste, raw slurry deposit.

INTRODUCTION

Agriculture accounts for the largest share of greenhouse gas emissions in Brazil (Toleffson, 2013). In 2010, the sector was responsible for about 35% of Brazil's emissions, from which approximately 4,9% corresponded to emissions from livestock manure management (MCTI, SEPED, CGMC, 2013).

The current manure management most used in Brazilian swine facilities consists in storing the slurry or liquid manure in open earthen deposits outside the animal housing followed by its spread on crops or pasture as an organic fertilizer. Nevertheless, there has been an environmental policy program called Low Carbon Agriculture Program (in Portuguese – *Programa ABC*) since 2010, which encourages and supports the installation of manure treatment technologies that could mitigate greenhouse gas (GHG) emissions. This initiative is aimed at helping the Country to meet climate goals announced in Copenhagen 2009, when Brazil made a commitment to reducing its GHG emissions by 36-39% by 2020.

Anaerobic digester/covered lagoon (responsible for trapping and burning biogas) and composting are both technologies included in *Programa ABC* for swine manure treatment. In spite of that, there is lack of information about the real reduction (in percentages) that could be reached by adopting these treatments under Brazilian conditions.

Global warming potential (GWP) is a worldwide used parameter that expresses how much heat the greenhouse gases emitted by a certain source can retain in the atmosphere. Therefore, the aim of this work is to monitor and compare emissions of CO_2, CH_4 and N_2O from three management/treatment systems that are used in Brazil: raw slurry deposit, open lagoon post-anaerobic digester and composting (sawdust + piggery slurry) in order to estimate the Global Warming Potential (GWP) of each technology.

MATERIAL AND METHODS

The experiment was conducted at Embrapa Swine and Poultry, located in the municipality of Concordia, Santa Catarina, Brazil. Monitoring of gases (CO_2, CH_4 and N_2O)

was conducted in three systems for management and treatment of swine manure, in a period of 180 days (from August 22/2013 to February 18/2014). The experiment consisted in three treatments with three replications. Treatments were composting, raw slurry deposit and open lagoon post-anaerobic digester, which were developed in nine reactors, each with 3 m^3.

The composting process was conducted by mixing fresh pig slurry with 400 kg of sawdust in a total of six applications distributed over time (days): 300 L (1), 300 L (7), 300 L (14), 300 L (28), 100 L (48), 100 L (55). To promote aeration the compost pile was mixed every three days. The leachate produced during the process was collected and reintroduced onto the piles. The same frequency and volume of manure used for composting was supplied to the slurry deposits and to the lagoons (swine effluent from an anaerobic digester instead of raw manure).

Emissions of CO_2, CH_4, and N_2O were measured using a dynamic chamber connected to a multipoint, with a continuous streaming air outlet of 2 m^3/h. The gases concentrations were measured every 20 minutes by Photoacoustic Gas Monitor (INNOVA 1412).

The total emission of each gas in the period evaluated for each experimental unit was calculated by integrating data of graphics of average emission rate of each day vs. days during the whole period when the systems was evaluated. The emission rate (g/h) was calculated with the equation 1.

$$\mathbf{F = Q \cdot (C_0 - C_i)} \qquad (1)$$

Where: *F* is the emission rate (g/h), *Q* is the air flow (m^3/h), Co and Ci are the concentration of the exit gas and the inlet gas (g/m^3), respectively.

The Global Warming Potential (GWP) was obtained from the equation 2:

$$\mathbf{GWP = CO_2 + 34\ CH_4 + 298\ N_2O} \qquad (2)$$

Data were evaluated by analysis of variance for the model, considering only the effect of the waste treatment used (SAS, 2008).

RESULT AND DISCUSSION

Results in Figure 1 showed that composting was very effective in reducing CH_4 emissions, when compared to slurry storage. That had already been expected as it is an aerobic process. Therefore, emissions of CO_2 as well as N_2O were intensified in composting, because it accelerates the organic matter degradation and stabilization. It was found that composting lost about 32 kg of carbon as CO_2, one kg as CH_4, and 250 g of nitrogen as N_2O. The raw slurry deposit had an accumulated carbon emission of almost 4,8 kg as CH_4. The open lagoon post-anaerobic digester presented low emissions of greenhouse gases, with cumulative emissions of 0,8 kg of CH_4-C; that occurred because most of the organic matter of swine manure was mineralized in the anaerobic digester (70-80%).

After 180 days of monitoring, this study showed that the composting had higher GPW, with 200 g eq CO_2 per kg of manure; emissions of N_2O accounted for 42,3%, CO_2 for 39,2%, and CH_4 for 18,5%. The raw slurry deposit had 165 g eq CO_2 per kg of manure; emissions of CH_4 contributed with 92,6% of GWP and CO_2 with 7%. The system (anaerobic digester + open lagoon) had 78 g eq CO_2 per kg of manure (considering a flare installed in the digester and burning the biogas with 98% of efficiency). The open lagoon post-anaerobic digester emitted 26 g eq CO_2 per kg of manure and almost whole GWP may be credited to CH_4 emission with 96,8% of CO_2 equivalent.

Corroborating these results, Higarashi et al (2013) conducted a study that compared the emissions of greenhouse gases (CH_4, CO_2, and N_2O) in the storage and composting of liquid swine manure within 40 days, and observed that in the swine manure lagoon the GWP was equal to 9,46 grams CO_2 equivalent. Emissions of CH_4 and CO_2 corresponded to 97,6 % and 2,7 %, respectively. In composting, the authors found that the GWP was equal to 16,08 g CO_2 equivalent; CO_2 accounted for 55,7 %, CH_4 for 20,3%, and N_2O for 24 %.

Emissions of N_2O and CO_2 are low or zero in lagoons and storage of pig slurry due to the ongoing maintenance of anaerobic conditions; the origin of these emissions is in the crust formed on the liquid waste stored (Wood et al, 2014). Whereas, in the composting, emissions of N_2O and CH_4 occur due to increased density of the mass, since it forms two microenvironments with low and high O_2 concentration, which favors the presence of methanogen, nitrifying, and denitrifying microorganisms (Chadwick et al, 2011).

Thus, was noticed that, comparatively, the open lagoon post-anaerobic digester issued less greenhouse gases. However, composting has the potential to reduce greenhouse gases, but technological development is necessary to reduce losses of nitrogen in the form of N_2O; as well as handling techniques should be used to reduce the emission of CH_4 in storage systems.

CONCLUSION

The open lagoon post-anaerobic digester has the lowest GPW, followed by raw slurry deposit and composting. Emissions from the subsequent use of these residues in the soil as fertilizer must be considered in future issues as compost tends to emit less GHG during this stage compared to liquid effluents. Although the GPW of the whole cycle of production and the utilization of swine manure in both liquid and solid form are required, the results of this work showed that composting is a technology that demands studies in order to mitigate N_2O emission.

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Figure 1: Accumulated emissions of CO_2-C, CH_4-C and N_2O-N throughout the processes of composting, swine manure storage, and anaerobic digester lagoon.