Title	Biogas Generation Capacity From A Stratified Farrow-To-Wean Production Unit And Solid Separation Influence On Methane Yield
Keywords	BMP test, solid-liquid separation, swine manure
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Short CV for Introduction **Purposes (10 lines max.)**	Master degree in Chemistry from the Midwestern State University- Unicentro, of Guarapuava, Paraná State. Currently are doing PhD in Agricultural Engineering from the State University of West Paraná, Unioeste, Cascavel/Brazil. Have expertise in swine wastewater treatment and biogas yield.
Photograph attached (jpg)	

BIOGAS GENERATION CAPACITY FROM A STRATIFIED FARROW-TO-WEAN PRODUCTION UNIT AND SOLID SEPARATION INFLUENCE ON METHANE YIELD

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Introduction

Brazilian swine production is organized according to the market necessity and regional characteristics. Farrow-to-wean swine production systems are increasing importance in Brazil due to the possibilities to have more specialized units (Miele and Miranda). Inside these systems, Gestating Sows Houses (GSH) and Farrowing Sows Houses (FSH) represent about 72% and 19% respectively, of all swine breeder in a typical farrow-to-wean unit (Dias et al., 2010).

The manure characteristics are influenced by factors as swine age and diet. The variation in methane potential of the effluent streams can be linked to the variation in production management practices such as feed, feeding techniques and effluent handling methods (Gopalan et al., 2012; Jarret et al., 2012).

Swine waste management strategies in Brazil are represented mainly by short storage in reception pits and land application (Kunz et al., 2009). Anaerobic digestion has been intensified in recent years, mainly by geomembrane covered lagoons, due to low cost and operational aspects. However, these biodigestors present limitations owing to the process low technology and low organic loading rate (around 0.5 kgVS m^{-3} d^{-1}), high solid retention time (> 45 dais), low total solids concentration (< 3 %) and low biogas productivity (Bortoli et al., 2009; Vivan et al., 2010).

Swine manure biogas generation can be improved by use of better biodigestion technologies, increasing substrate solid concentration, as co-digestion or a preliminary solid-liquid separation process as mechanical separators or screens (Hjorthet al., 2010, Deng et al., 2012; Sutaryo et al., 2013).

Thus, this study aimed to evaluate biogas and methane production from biomass of swine production different stages (gestating and farrowing sows) and the influence of solids separation strategies.

Material and methods

Samples: Swine manure samples were collected from two pits (GSH and FSH) of a farrow-to-wean with 500 sows in Concórdia, Santa Catarina State-Brazil (none of the sampled sites used any bedding material).

Samples pre-treatment: The raw manure (RM) samples from GSH and FSH were screened in 2 mm sieve and the screened fraction settled for 1 h. The solid retained on sieve (SRS) and the settled sludge (StS) were performed to BMP tests.

Biomethane potential (BMP): BMP tests were carried out at mesophilic temperature conditions according German Standard Procedure VDI 4630 (2006). The biogas measures during the running test were performed in monitored conditions of temperature and pressure corrected to normal temperature and pressure (NTP). The batch tests were proceeded in 250 mL reactor flask's and the gas volume was measured using eudiometer graduates tubes. The mesophilic anaerobic inoculum was acclimated biomass according Steinmetz et al (2014), prepared from equal parts (1 +1 +1) of: a) anaerobic sludge from UASB reactor fed with swine manure, b) anaerobic sludge from UASB reactor of food industry and c) fresh dairy cattle manure. Two weeks before the test, the mixture of biomass was acclimatized (37 ± 1 °C) in a completed mixing reactor, fed at the rate of 0.3 kgVS.m^{-3}.d^{-1} for 7 consecutive days. Then, the inoculum remained 7 days without fed, in order to reduce the biogas baseline production.

BMP tests were performed for RM, SRS and DS. The presented values from supernatant (SN) were estimated by biogas and volatile solids mass balance.

Biogas analyses: For evaluation of the biogas composition biogas samples were collected from eudiometer using aluminum bag and analyzed by photoacoustic gas analyzer (INNOVA model 1412 LummaSense Technologies Inc.).

Results and discussion

To investigate the different solids fractions and supernatant impacts on biogas and methane yields mass balance of volatile solid for GSH and FSH were performed. For two samples, the raw manure was considerate 100% and the contributions of each fraction were determined (Table 1).

Table 1. Mass balance of volatile solid (VS) based on the raw swine manure and derived fractions from solid separation for gestating sows house (GSH) and farrowing sows houses (FSH).

Sample	VS/TS ratio %	Volatile solid $kg.VS^{-1}$	x_m
	GSH		
RM	67.3	23.07	1
SRS	73.9	4.94	0.231
StS	70.1	11.29	0.489
SN	66.1	6.8	0.296
	FSH		
RM	65.7	26.12	1
SRS	79.9	5.21	0.199
StS	64.3	16.42	0.629
SN	62.6	4.39	0.168

X_m: mass fraction of total volatile solid in RM

The BMP tests results of GSH and FSH waste were presented in Table 2. These results demonstrate the difference in volatile solids degradability of different fractions presents in each sample and the contrast between GSH and FSH biogas potential.

Table 2. Biogas and methane yields for gestating sows house (GSH) and farrowing sows houses (FSH) waste**.**

Sample	Biogas yield $L_{Nbiogas}.kg^{-1}_{raw\ manure}$	Biogas yield $Nm^3.kgVS^{-1}$	% CH_4	Methane yield $Nm^3.kgVS^{-1}$	Methane yield $L_{Nmethane}.kg^{-1}_{raw\ manure}$
			GSH		
RM	13.3	0.577	53.7	0.310	7.1
SRS	2.3	0.475	50.1	0.238	1.2
StS	4.8	0.429	41.6	0.178	2.0
SN	6.1	0.900	64.7	0.582	4.0
			FSH		
RM	6.5	0.479	52.2	0.250	6.5
SRS	1.3	0.534	48.3	0.258	1.3
StS	4.0	0.475	51.9	0.247	4.0
SN	1.1	0.524	59.0	0.260	1.1

The GSH supernatant fraction had a higher general contribution, which accounts methane for 4.0 $L.kg^{-1}$ of RM. That is about 56% of methane potential of GSH raw manure. Similar results were found in literature, where, Qiao et al., (2011), in batch tests, achieved methane yield per kg of volatile solids to approximately 60% higher when used only supernatant compared to raw manure. In continuous test, Kunz and Encarnação (2007), reported biogas production of 1.43 $m^3.KgSV^{-1}_{add.,}$ for an UASB reactor fed with swine effluent submitted to a previous solid-liquid separation process. The enhancement in the supernatant fraction supported the fact that organic matter in this fraction is at soluble form and more available to microorganisms.

The kinetic study for GSH show that RM and StS samples evidence a maximum specific biogas rate (138.5 and 123.8 $Nm^3.kgVS^{-1}d^{-1}$, respectively) on the first day of test, but for SRS fraction (80.6 $Nm^3.kgVS^{-1}d^{-1}$) was reached on the 9th day of test, which indicates a lag phase due possible limitation for hydrolysis. Gonzalez-Fernandez et al., (2008) achieved 90% of the methane production during the first 15 days for the liquid samples and 24 days were needed for the solids ones, demonstrating the bioavailability difference between the phases.

The FSH waste sample presented methane yield of 6.5 $L.kg^{-1}$ of RM. The StS fraction has a higher general contribution, which accounts methane for 4.0 $L.kg^{-1}$ of RM. That is about 62% of methane potential of FSH raw manure. The relationship between the volatile solids percentage contained in the SRS per StS was less for the FSH manure sample (1.05) than GSH manure sample (1.24), which may indicate an advanced stage of hydrolysis from the FSH effluent.

The kinetic study shows that the maximum specific biogas rate for RM, SRS and StS samples (117.2, 91.8, and 117.1 $Nm^3.kgVS^{-1}.d^{-1}$, respectively) were achieved on the first day of test, that indicate the ready bioavailability of organic matter by anaerobic microorganisms.

In terms of quality biogas, the supernatant fraction presented higher methane concentration for both samples (GSH and FSH) indicating that methane content of biogas was enhanced by screening and settling swine manure.

Conclusion

The biogas yield variation from different fractions (SRS, StS and SN) suggests that biodigester operating with SN fraction would produce more methane when compared to those operating with SRS and StS. Another indicator is the achieved maximum specific degradation rate, these values can be used to support decisions on hydraulic retention time needed to anaerobic digestion.

These results will be useful for a swine biogas plants (e.g. use a hydrolysis stage reactor for SRS phase from FSH) and can contribute to selection strategies of swine wastewater management or selection of anaerobic digestion technology.

Acknowledgements

The present research was supported by Eletrosul Centrais Elétricas S.A., Uirapuru Transmissora de Energia S.A., grant No 1110130054 (Chamada No 14/2012 – ANEEL).

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