








EVALUATION OF THE PERFORMANCE OF COVERED LAGOON DIGESTER IN TERMS OF THE SOLIDS LOADING

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ABSTRACT

The use of anaerobic digesters to convert residual biomass for energy use and nutrient recovery has been increasingly indicated by the operational simplicity and added value of the treatment by-products. However, the levels of solids present in the influents to be treated directly influence the operation and management of the system. Thus, the objective of the study was to evaluate the performance of covered lagoon digesters in terms of the solids loading in the swine wastewater treatment system. The study was performed in a farm located in Zona da Mata Mineira. The monitoring took place from September 2018 to August 2019. The influent flow of waste was estimated based on the analysis of monthly water consumption on the farm. The collection and sampling took place weekly, the influents and effluents were analyzed in terms of the solids loading of total solids (TS) and volatiles solids (VS). The mean total flow distributed to the two digesters was $102.3 \text{ m}^3 \cdot \text{d}^{-1}$, with a mean hydraulic retention time (HRT) of 24.5 days. The results ranged from 1.14 to 2.83% for TS at the start of treatment. In most of the monitored months, anaerobic digesters were being fed with organic overload in terms of VS, which consequently affected the efficiency of the system, which were 33.6% for TS and 39.5% for VS.

Palavras-chave:

Digestão anaeróbia
Suinocultura
Tratamento de resíduos

AVALIAÇÃO DO DESEMPENHO DE BIODIGESTORES MODELO LAGOA COBERTA EM TERMOS DO APORTE DE SÓLIDOS.

RESUMO

A utilização de biodigestores anaeróbios como meio de conversão de biomassa residual para aproveitamento energético e recuperação de nutriente vem sendo cada vez mais indicada pela simplicidade operacional e valor agregado dos subprodutos do tratamento. Todavia, os teores de sólidos presentes nos afluentes a serem tratados influenciam diretamente na operação e manejo do sistema. Assim, o objetivo do estudo foi avaliar o desempenho de biodigestores lagoa coberta em termos do aporte de sólidos no sistema de tratamento de efluentes de suinocultura. O estudo foi realizado em uma granja localizada na Zona da Mata Mineira. O monitoramento ocorreu no período de setembro de 2018 a agosto de 2019. A vazão afluente de dejetos foi estimada a partir da análise do consumo mensal de água na granja. A coleta e amostragem ocorreu semanalmente, os afluentes e efluentes foram analisados em termos de sólidos totais (ST) e voláteis (SV). A vazão média total distribuída aos dois biodigestores foi de $102,3 \text{ m}^3 \cdot \text{d}^{-1}$, com tempo de retenção hidráulica (TRH) médio de 24,5 dias. Os resultados apontaram uma variação de 1,14 a 2,83% para ST na entrada do tratamento. Na maioria dos meses monitorados, os biodigestores anaeróbios estavam sendo alimentados com sobrecarga orgânica em termos de SV, o que consequentemente, afetou a eficiência do sistema, equivalente a 33,6% para ST e 39,5% para SV.

INTRODUCTION

Among Brazilian states, Minas Gerais stands out for being the fourth largest pig producer, accounting for 11% of the country's total production (ABPA, 2020). However, the majority of pig farming in the region have herds in a confined regime, which implies a high generation of manure with high organic concentrations.

Anaerobic digestion has become an attractive route for the treatment of influents, due to its high potential for energy recovery from methane (CH_4) and the possibility of using biofertilizer for plant nutrition in order to reduce the use of chemical fertilizers (MORGAN *et al.*, 2018; NAGARAJAN *et al.*, 2019).

However, the solids content in the influents is an extremely important factor when seeking energy recovery from CH_4 , as it indicates the total biomass to be degraded, so that in the anaerobic process only the fraction of organic origin will be removed (LEITE; POVINELLI, 1999). The organic fraction is represented by the levels of volatile solids (VS) present in the influents, thus, the greater the portion of VS the greater the possibility of biogas production (HASAN *et al.*, 2019). In addition, the content of solids in the influent is an important parameter to be considered due to the need for a pre-treatment, as well as choosing the most appropriate digester model for the influents to be treated (KUNZ *et al.*, 2019).

Among the various configurations of digesters

in Brazil, the use of covered lagoon digesters (CLD) stands out, which have a lower construction cost and storage capacity of the gas generated (AMARAL *et al.*, 2016; CALZA *et al.*, 2015). Therefore, the objective of this study was to evaluate the performance of covered lagoon digesters in terms of the contribution of solids in the swine wastewater treatment system.

MATERIAL AND METHODS

The monitoring of solids was performed in a pig farming located in the Zona da Mata Mineira. The farm's influent treatment system consists of two covered lagoon anaerobic digesters operating in parallel followed by three facultative lagoons. The farm has 10,695 pigs, 1,631 sows and 14 boars.

The monitoring took place from September 2018 to August 2019. The influent flow of manure was obtained from the analysis of monthly water consumption on the farm for the period studied and the adoption of a return coefficient of 0.65 reported by Souza *et al.* (2017). The volumetric capacity of each CLD is 1,250 m^3 . The influent collection and characterization was performed weekly, and the sampling points are indicated in Figure 1. The monitoring was performed in terms of total solids (TS) and volatiles (VS). The discussions were carried out considering the mean values between the two CLD.

The percentage of TS present in the influent, volumetric organic loading rate in terms of VS and

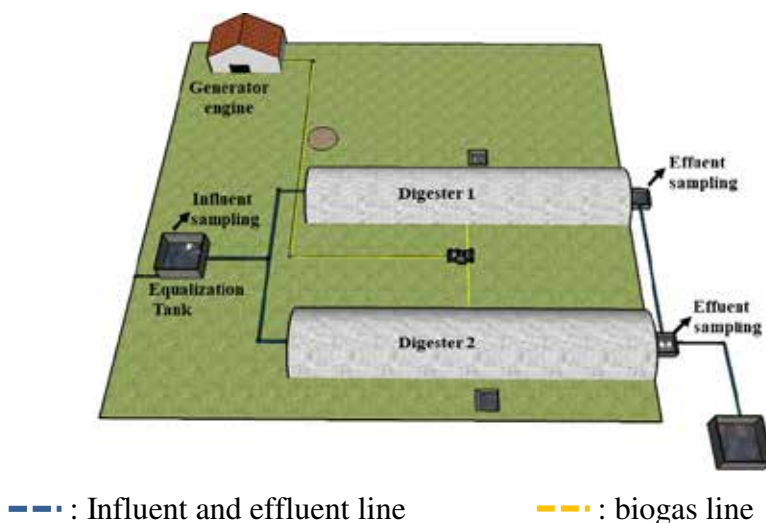


Figure 1. Sketch of the swine wastewater treatment system.

removal efficiency of TS and VS were quantified in order to evaluate the operating conditions of the digester.

RESULTS AND DISCUSSION

The variations in the effluent flow rates is shown in Figure 2-A. The mean value considering the total influent distributed to the two digesters for the period was $102.3 \text{ m}^3 \cdot \text{d}^{-1}$, resulting in an HRT of 24.5 days. According to Palhares and Gebler (2014) the HRT in digesters of this configuration ranged from 20 to 40 days, being in accordance with the typical range reported in the literature.

The TS content in the influent ranged from 1.1 to 2.8%, with a mean value of 2.1% (Figure 2-B). The TS concentrations at the entrance of the system are in accordance with the range reported by Kunz *et al.* (2019), being 3%. In terms of volumetric organic loading rate, we could observe that most of the monthly mean were above the range reported by Kunz *et al.* (2019) as ideal (0.3 to $0.5 \text{ kgVS} \cdot \text{m}^{-3} \cdot \text{d}^{-1}$) (Figure 2-B). The average was $0.63 \text{ kgVS} \cdot \text{m}^{-3} \cdot \text{d}^{-1}$ for the period. The levels of solids applied in the system rule out the need for preliminary treatment.

In Figure 3 is shown the levels of solids in the systems in terms of total and volatile solids, as well as their removal efficiencies in the digesters.

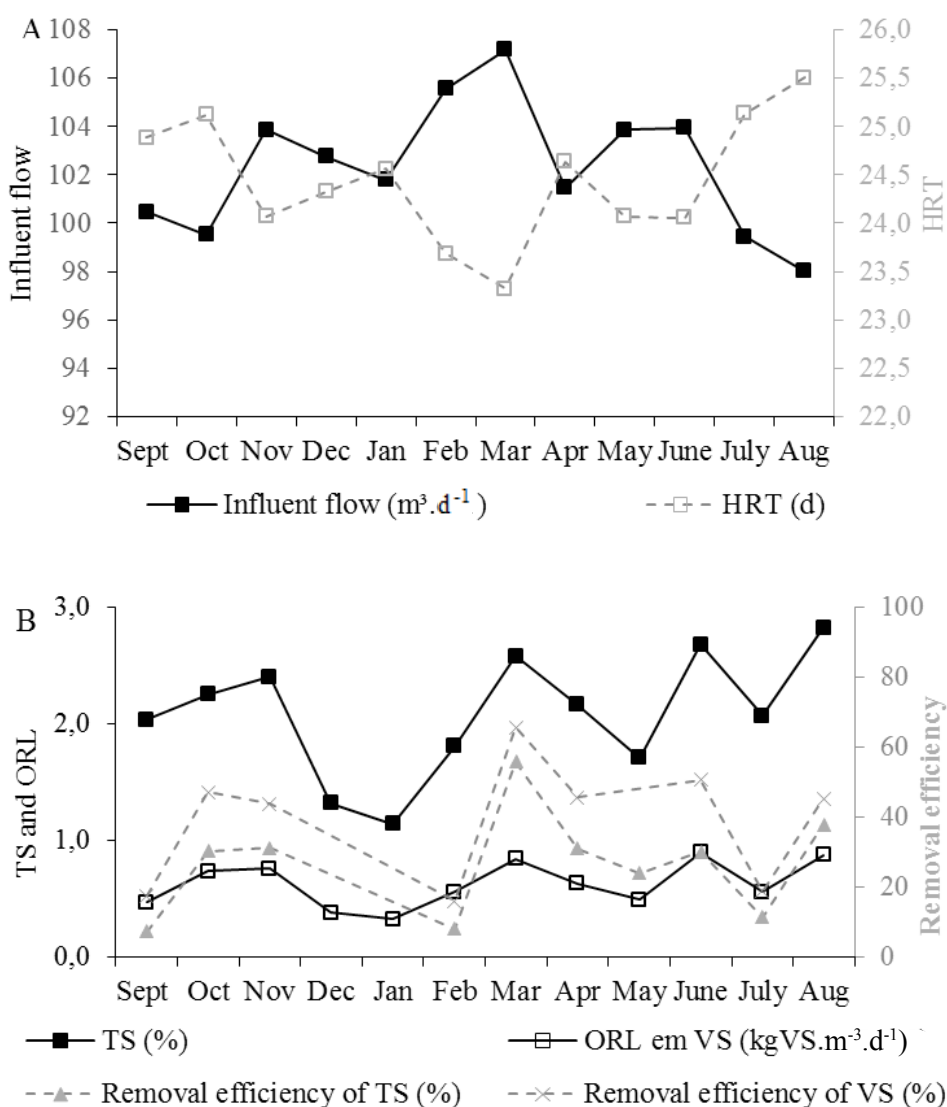


Figure 2. Time series of influent flow and hydraulic retention time (HRT) (A); and the concentration of TS applied to the system, as well as the volumetric organic loading rate (ORL) in terms of VS and the removal efficiency of TS and VS (B)

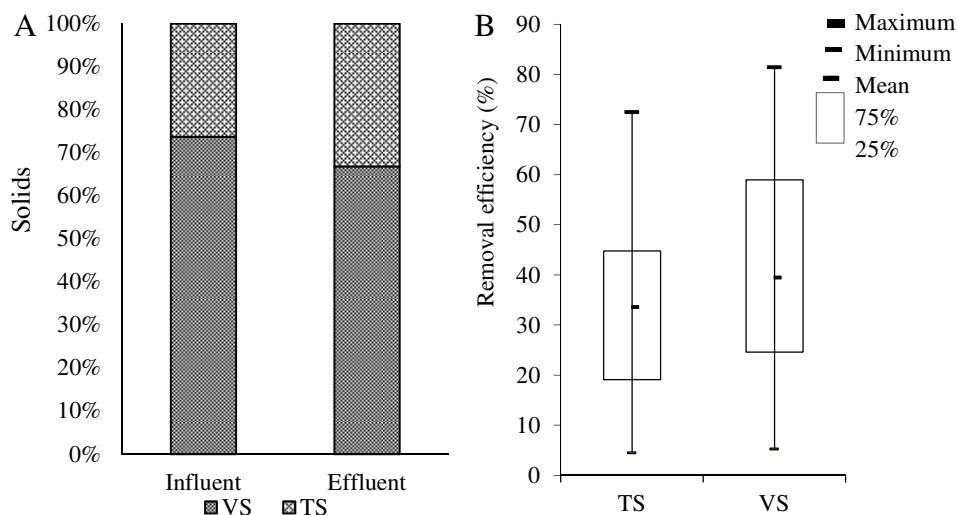


Figure 3. Percentage of volatile solids (VS) present in total solids (TS) (A) and box-plot graph of the removal efficiency of solids (B) in the periods from Sept.2018 to Aug.2019

In Figure 3-A, we can observe that the VS/TS ratio in the influent applied in the CLD was of 73.6%, indicating a high potential for biodegradability for the swine wastewater. The organic fraction is in accordance with the data presented by Oliveira and Higarashi (2006), which ranged from 70 to 75%.

The removal efficiency of TS and VS were 33.6 and 39.5%, respectively (Figure 3-B). However, the reduction values of the solid series were lower than that reported by Veloso *et al.* (2018), which obtained TS and VS removal efficiencies equal to 67.6 and 71.8%, respectively. This low system efficiency may be associated with organic overload in terms of VS. To improve the efficiency it is proposed operational interventions, such as: increase of HRT to allow the organic fraction (VS) degradation as well as the installation of equipment for remove solids in the influent.

CONCLUSION

- From the monitoring of digesters, we could observe that the levels of solids applied in the system rule out the need for preliminary treatment.
- The digesters are operating under volumetric organic loading rate overload in terms of VS, which consequently affected the efficiency of the system, which obtained values of 33.6% for TS and 39.5% for VS. The removal of solids in

a preliminary treatment as well as a longer time for organic fraction degradation may improve CLD efficiency.

- The monitoring of digesters, in terms of the contribution of solids, contributes to the decision-making in pig farming, on the dilution of influents and possible changes in the HRT.

AUTHORSHIP CONTRIBUTION STATEMENT

SOUSA, I.P.: acquisition of data, analysis and interpretation of data, drafting and revising the work. ROSA, A.P: supervision and conception of the research, analysis and interpretation of data, drafting and revising the work. LOPES, J.O: acquisition of data, analysis and interpretation of data, revising the work. BORGES, A.C.: interpretation of data, revising the work, MAGOS, B.R.: revising the work. SOARES, M.S.: acquisition of data.

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We have no conflict of interest to declare.

REFERENCES

- ABPA. Associação Brasileira de Proteína animal. Relatório anual, São Paulo, 2020.
- AMARAL, A. C.; KUNZ, A.; STEINMETZ, R. L. R.; SCUSSIATO, L. A.; TÁPARRO, D. C.; GASPARETO, T. A. Influence of solid-liquid separation strategy on biogas yield from a stratified swine production system. **Journal of environmental management**, v.168, p. 229-235, 2016.
- CALZA, L. F.; LIMA, C. B.; NOGUEIRA, C. E. C.; SIQUEIRA, J. A. C.; SANTOS, R. F. Avaliação dos custos de implantação de biodigestores e da energia produzida pelo biogás. **Engenharia Agrícola**, Jaboticabal, v.35, n.6, p. 990-997, 2015.
- HASAN, C.; FEITOSA, A. K.; SILVA, M. C. A.; MARDER, M.; KONRAD, O. Produção de biogás a partir de resíduos agroindustriais: análise dos teores de sólidos totais, voláteis e fixos em amostras pré digestão anaeróbia. **Revista Brasileira de Energias Renováveis**, v. 8, n. 1, p. 257-273, 2019.
- KUNZ, A.; STEINMETZ, R. L. R.; AMARAL, A. C. Fundamentos da digestão anaeróbia, purificação do biogás, uso e tratamento do digestato. 1. ed. Concórdia: Sbera: Embrapa Suínos e Aves, 2019.
- LEITE, V. D.; POVINELLI, J. Comportamento dos sólidos totais no processo de digestão anaeróbia de resíduos sólidos urbanos e industriais. **Revista Brasileira de Engenharia Agrícola e Ambiental**, Campina Grande, v.3, n.2, p. 229-232, 1999.
- MORGAN JR, H. M.; XIE, W.; LIANG, J.; MAO, H.; LEI, H.; RUAN, R.; BU, Q. A techno-economic evaluation of anaerobic biogas producing systems in developing countries. **Bioresource Technology**, v.250, p. 910-921, 2018.
- NAGARAJAN, D.; KUSMAYADI, A.; YEN, W.; DONG, C.; LEE, D.; CHANG, J. Current advances in biological swine wastewater treatment using microalgae-based processes. **Bioresource technology**, v.289, p. 121718, 2019.
- OLIVEIRA, P. A. V. DE; HIRAGASHI, M. M. Geração e utilização de biogás em unidades de produção de suínos. **Documentos / EMBRAPA**, Concórdia, v. 1, p. 42, 2006.
- PALHARES, J. C. P.; GEBLER, L. Gestão ambiental na agropecuária. 1. ed. Brasília: EMBRAPA, v.2, 2014.
- SOUZA, J. C. P.; OLIVEIRA, P. A. V.; TAVARES, J. M. R.; BELLI FILHO, P.; ZANUZZI, C. M. S.; TREMEA, S. L.; PEIKAS, F.; SQUEZZATO, N. C.; ZIMMERMANN, L. A.; SANTOS, M. A.; AMARAL, N. Gestão da Água na Suinocultura, **Documentos / EMBRAPA**, Concórdia, 2017.
- VELOSO, A. V.; CAMPOS, A. T.; MARIN, D. B.; MATTIOLI, M. C.; NPERI, A. C. Sustentabilidade ambiental da suinocultura com manejo de dejetos em biodigestor-avaliação de parâmetros físico-químicos. **Revista Engenharia na Agricultura**, Viçosa, v.26, n.4, p. 322-333, 2018.