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Technical Note

Performance of two swine manure treatment systems on chemical composition and on the reduction of pathogens

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HIGHLIGHTS

- Lagoon and compact treatment system reduce chemical and microbial from swine manure.
- Chemical and microbial reduction was better after lagoons treatment due to high HRT.
- Adenovirus showed to be a good environmental contamination marker.

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ABSTRACT

Swine effluents must be correctly handled to avoid negative environmental impacts. In this study, the profiles of two swine manure treatment systems were evaluated: a solid–liquid separation step, followed by an anaerobic reactor, and an aerobic step (System 1); and a biodigester followed by serial lagoons (System 2). Both systems were described by the assessment of chemical, bacterial and viral parameters. The results showed that in System 1, there was reduction of chemicals (COD, phosphorus, total Kjeldhal nitrogen – TKN – and NH_3), total coliforms and *Escherichia coli*; however, the same reduction was not observed for *Salmonella* sp. Viral particles were significantly reduced but not totally eliminated from the effluent. In System 2, there was a reduction of chemicals, bacteria and viruses with no detection of *Salmonella* sp., circovirus, parvovirus, and torque teno virus in the effluent. The chemical results indicate that the treated effluent can be reused for cleaning swine facilities. However, the microbiological results show a need of additional treatment to achieve a complete inactivation for cases when direct contact with animals is required.

1. Introduction

Swine production is a rapidly growing industry. This is especially true in Brazil, which is the fourth largest swine producer (3.36 Mt yr^{-1}), the fourth largest exporter (0.52 Mt yr^{-1}), and the sixth largest consumer (15 kg yr^{-1} $person^{-1}$) in the world (ABIPECS, 2011). Furthermore, there has been an increase of swine manure generation and swine-related water consumption. It is estimated that 6 m^3 of water is necessary to produce 1 kg of pork (Palhares, 2011).

Swine effluent contains pig urine, feces, water spillage, remains of undigested feed items, antimicrobial drug residues and pathogenic microorganisms. Considering these characteristics, it is recommended that this material be correctly managed before its application to land to avoid potential environmental contamination (Hundesa et al., 2009). Recent studies have proposed treatment strategies for swine manure that include physical, chemical and biological processes designed for the effective removal of organic compounds and the inactivation of bacteria (Vanotti et al., 2005; Costantini et al., 2007). In Brazil, the predominant manure management strategy currently adopted is pit storage followed by land application (Kunz et al., 2009). For treatment, the most commonly used option is the anaerobic treatment/covered lagoon system (Pérez-Sangrador et al., 2012).

Commonly, swine manure is characterized by a high content of suspended solids, organic matter, and high phosphorus and nitrogen contents (Steinmetz et al., 2009). Additionally, high levels of microbial populations are observed including total coliforms, *Escherichia coli*, and *Salmonella* sp. (Hutchison et al., 2005). Viruses as adenovirus, torque teno virus, parvovirus and circovirus have also been observed. These microorganisms are important when

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considered the ramifications for both human and animal biosecurity (Martens and Böhm 2009).

Salmonella is a rod-shaped, Gram-negative bacteria, belonging to the genus *Salmonella* (*S.*), family Enterobactereaceae. *Salmonella* colonizes the intestinal tract of animals and humans. Over 2500 serovars have been classified according to antigen composition. Animals can be infected with a wide variety of serovars that may or may not clinically manifest in the host (Griffith et al., 2012). Coliforms are a group of bacteria functionally-related that belong to different genera (*Echerichia, Citrobacter, Enterobacter* and *Klebsiella*), where 80% of coliform bacteria are represented by *E. coli* and are used as biological indicator of the sanitary quality for water and food (Tortora et al., 2005).

Porcine adenovirus (PAdV), porcine circovirus (PCV2), porcine parvovirus (PPV1) and torque teno virus (TTV) are non-enveloped DNA viruses that have been reported to be widespread within swine populations (Hundesa et al., 2009; Shangjin et al., 2009). PCV2 is associated with Post-weaning Multisystemic Wasting Syndrome (PMWS), and PPV causes reproductive failure in swine (Shangjin et al., 2009).

In contrast with the swine production, the environmental legislation regarding the security parameters is recent. In Brazil, the Resolution CONAMA 430 (CONAMA, 2011) is used to guide the discharge on effluent in water bodies. However, nothing has been established about the security parameters for the water reuse on animal production. Concerning the described above and the reusing of water from treated manure, the present work aimed to evaluate the water quality from two distinct swine manure treatment systems considering the capacity on abatement of chemical and microbiological parameters.

2. Materials and methods

2.1. Treatment systems

The facilities were located at Embrapa Swine and Poultry, Concórdia, SC, Brazil. System 1 received piggery wastewater from Embrapa's experimental facilities (15 $m^3\ d^{-1}$). The treatment system consisted of a solid–liquid separation step using a screen, an equalization tank, a settling tank, an anaerobic reactor, an aerobic reactor and a second settling tank (Kunz et al., 2009). System 2 consisted of a anaerobic digester followed by serial lagoons (anaerobic, facultative, and maturation). (Techio et al., 2011). The schematic representation of both systems is shown in Fig. 1.

2.2. Manure sampling sites

A total of 86 piggery samples from the two manure management treatment systems were collected from March 2009 to December 2010. The samples were collected once a month (except in Oct/09, Dec/09, Jan/10 and Feb/10 (both systems) and May/10, June/10, September/10 and October/10 (System 2) due to systems operational problems. The sampling sites in the System 1 were located as follows: site 1 after the equalization tank (representing the raw manure), site 2 after the solid–liquid separation, and site 3 represented the treated wastewater (after the biological steps). Sampling sites in the System 2 were located before (site 1) and after (site 2) anaerobic digester, site 3 after the maturation lagoon to represent the treated wastewater. All the sampling events were performed at the same day in the morning.

2.3. Sample storage and chemical analysis

1 L of each sample was collected in a polyethylene flask and stored at 4 °C before analysis COD, total phosphorus (TP), nitrogen (TKN and NH_3) were determined according to APHA (2005).

2.4. Bacterial analysis

Total coliforms and *E. coli* analysis were performed using the Petrifilm *E. coli*/Coliform Count Plate kit (USA), following the manufacturer's instructions. *Salmonella* quantitative detection was obtained using the Most Probable Number (MPN) assay, performed according to Bacteriological Analytical Manual (BAM, 2003).

2.5. Viral analysis

20 mL samples were collected from each site. Samples were concentrated, and submitted to DNA extraction as described by Viancelli et al. (2011). For PPV, TTV, PAdV and PCV2 detection, DNA was submitted to qualitative PCR (qPCR) following the protocols described by Soares et al. (1999), Segalés et al. (2009), Hundesa et al. (2009) and Viancelli et al. (2011), respectively. In the case of PAdV and PCV2 reactions, qPCR positive samples were

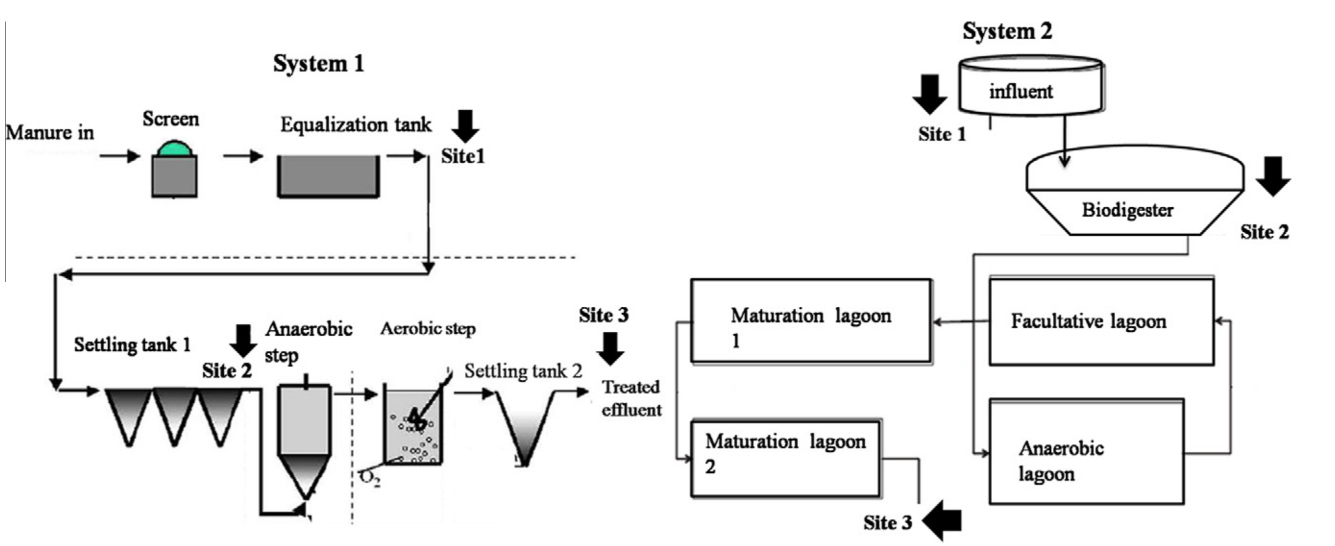

Fig. 1. Schematic representation of the two swine manure treatment systems analyzed in the present study. The sampling sites are indicated on both systems are indicated by black arrows. The sites represent the influent, the intermediate and the final effluent.