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Phytotoxicity of effluents from swine slaughterhouses using lettuce and cucumber seeds as bioindicators

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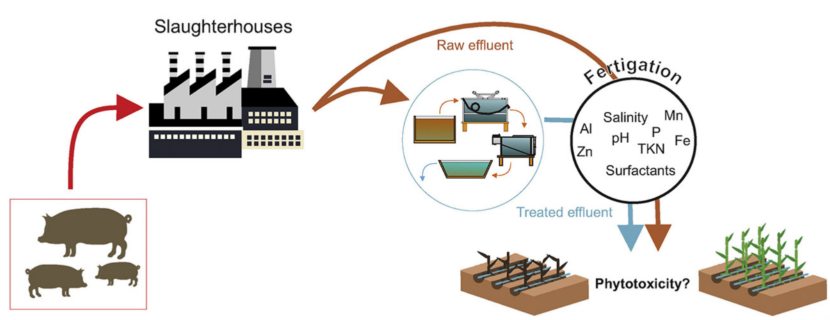
HIGHLIGHTS

- Physicochemical parameters of effluents from swine slaughterhouse were evaluated.
- Lettuce and cucumber seeds were used as bioindicators of phytotoxicity.
- Raw and treated effluents presented toxic effects for both tested seeds.
- The GI of lettuce seeds was negatively correlated with TKN and surfactants.
- There were negative correlations between Zn and the GI for both seeds.

GRAPHICAL ABSTRACT



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ABSTRACT

This study evaluated the phytotoxic effects of raw and treated effluents from a swine slaughterhouse on cucumber and lettuce seeds and determined correlations among physicochemical characteristics of such effluents and the germination of seeds used as bioindicators. Physicochemical parameters were characterized for both effluents and their phytotoxicity was determined through the germination index (GI), the root length (RL) and the number of germinated seeds (SG) for both plant species. The effluents treatment system was efficient to reduce the concentration of some physicochemical parameters to levels within those recommended by the Brazilian legislation, except for P, ammoniacal N and TKN concentration. Although phytotoxicity of the treated effluent was less in comparison to the raw effluent, the GI for cucumber and lettuce seeds submitted to each of the tested effluents was lower than 80%. Thus, both effluents were phytotoxic for the tested bioindicators ($p < 0.05$). For lettuce seeds, the GI presented negative correlations ($p < 0.05$) with the total Kjeldahl N (−0.93) and the surfactants concentration (−0.83) in the raw effluent. The Zn concentration in the treated effluent showed a negative correlation ($p < 0.05$) with the GI of both lettuce (−0.63) and cucumber seeds (−0.64). Therefore, effluents from swine slaughterhouses may impair the germination of the evaluated plant species if used for agricultural purposes.

1. Introduction

Brazil has an increasingly emergent swine industry (Mathews, 2014) and is ranked as the fourth largest pork producer in the world

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(Fiuza et al., 2016). Currently, there are 42 swine abattoirs in Brazil operating under the mandatory federal inspection guidelines of the Brazilian Ministry of Agriculture, Livestock and Supply, which emphasizes the key role of pork production for Brazilian agribusiness.

Pork processing demands great water consumption, generating a large amount of effluents that are potentially toxic for the environment (Rahamn et al., 2014). Abattoirs are among the leading pollutant industries, producing effluents containing organic nutrients, solids, oils (Thebaldi et al., 2011; Rabelo et al., 2014), phosphates, nitrates, nitrites and salts, commonly used in processing, and products used for cleaning and disinfection, such as alkaline solutions and detergents (Marcos et al., 2012). Nonetheless, due to their great nutrient content, effluents from abattoirs are frequently used in agriculture, because of many factors: their availability throughout the year (Blum et al., 2013); the poor content of N and P in Brazilian soils (Abdala et al., 2012); and the scarcity of water for soil irrigation (Masciandaro et al., 2014).

However, the agricultural use of industrial effluents may alter the physicochemical and microbiological characteristics of the soil and contribute for the accumulation of potentially toxic chemical and biological contaminants (Becerra-Castro et al., 2015). Even after treatment, effluents still contain high concentration of salts, toxic metals, bacteria and antibiotics, which may lead to undesirable effects on plants and soils (Pedrero et al., 2012; Ghava et al., 2015). Due to the complexity of the industrial effluents, the risk of environmental contamination related to their use in agriculture cannot be precisely assessed only through physicochemical evaluations (Smital et al., 2011). The phytotoxicity of such effluents should also be tested because of the wide range of their potential environmental effects (Yu et al., 2014).

Except for some studies about sugarcane vinasse (Blum et al., 2013; Christofoletti et al., 2013), there are limited information available on that subject. Thus, the impact of the application of effluents from swine slaughterhouses in agricultural soils still needs further investigation. Although toxicity tests for effluent disposal are mandatory in some countries. But, in Brazil only recently the legislation addressed the need toxicity evaluations on water resources to measure the impact of launching treated industrial effluents (Brasil, 2011). Prior to that, industrial effluents were evaluated only through physicochemical parameters (Pimentel et al., 2011). Seeds of plant species can be used as bioindicators to evaluate the phytotoxicity of effluents being applied to the soil (Goudier et al., 2010; Charles et al., 2011; Hashem et al., 2013; Cruz et al., 2013). These bioassays were successfully conducted to evaluate toxicity of residues, organic material and effluents (Ramana et al., 2002; Aviani et al., 2010; Özkara et al., 2011; Mitelut and Popa, 2011; Khan et al., 2014), due to their simplicity and to their sensitivity to distinct concentrations of different pollutants.

The objectives of this research were to evaluate the phytotoxicity of raw and treated effluents from a swine slaughterhouse on seeds of lettuce (*Lactuca sativa* L.) and cucumber (*Cucumis sativus* L.) and to determine correlations among physicochemical characteristics of such effluents and phytotoxicity indicators.

2. Material and methods

2.1. Description of the treatment system and sample collection

The research was conducted in a swine slaughterhouse with a sausage processing factory, located in southern Brazil (−31.7701°; −52.3423°), with structure like an average Brazilian industries. This industry is currently licensed as per the Brazilian environmental regulations, slaughtering 6000 pigs monthly and producing 270 ton of pork and different sausages, which corresponds to a maximum effluent release of 300 $m^3\ d^{-1}$. The system for effluent's treatment includes: pumping tank; hydrodynamic sieve; equalization/neutralization tank; dissolved air flotation system; aerated and facultative lagoons; system lagoon with emergent plants, with a hydraulic retention period of nearly 60 d (Fig. 1).

The raw effluent was collected from the pumping tank, whereas the treated effluent was collected after the effluent passed through the lagoons with emergent plants (Fig. 1). At the time of sampling, pH, temperature, electric conductivity (EC) and salinity were measured using a HI 9828 portable meter. Seven composite samples of raw and treated effluents were collected during eight months, only at slaughtering days, within intervals of approximately 35 days. The samples were collected hourly, during a period of 6 h. All samples were packaged, maintained at 4 °C and transported to the laboratory. As recommended by the APHA (2012), the following parameters were evaluated: biochemical oxygen demand – BOD (5120B); chemical oxygen demand (5220D); total suspended solids (2540D); total Kjeldhal nitrogen - TKN (4500 NORGB,C); ammoniacal nitrogen (4500 NH_3 B,C); total phosphorus (4500P,E); chlorides (4500C); surfactants (5540D); sulfides (4500 S, D); hardness (2340D); aluminium (3500B); manganese (3500B); iron (3500B); zinc (3111B); and phenols (5530C). All samples were evaluated in duplicate, totalling 14 samples per parameter and per treatment.

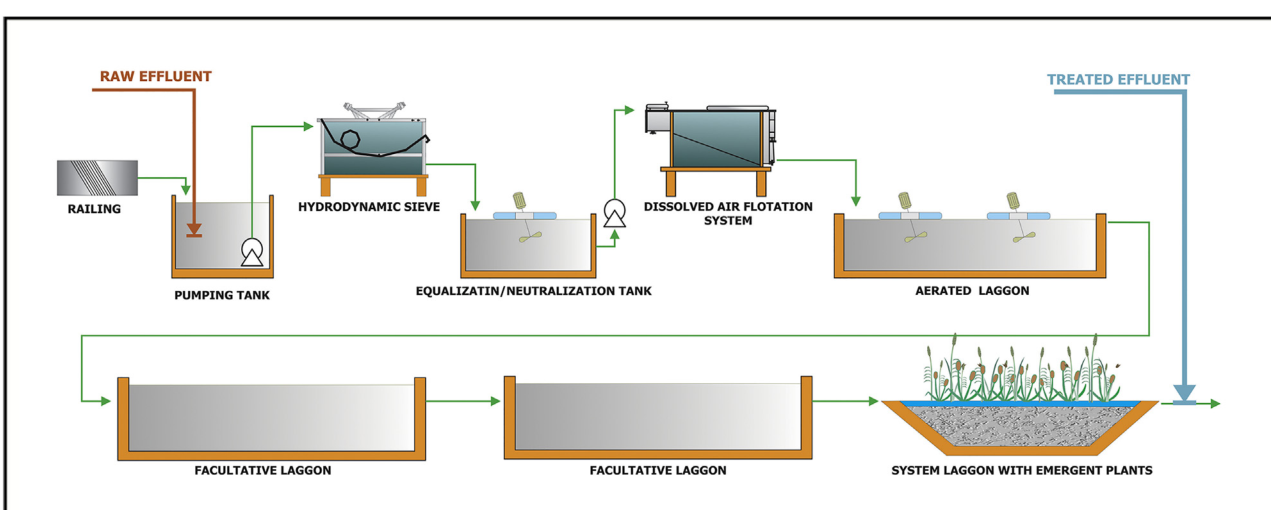

Fig. 1. Flowchart of the system for effluent treatment.