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Optimization of the specific methanogenic activity during the anaerobic co-digestion of pig manure and rice straw, using industrial clay residues as inorganic additive

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HIGHLIGHTS

- Rice straw and clay additive enhanced methane production on pig manure anaerobic digestion.
- Rice straw enhanced the cumulative methane production in long term.
- Clay reduced the inhibition effect of pig manure due to ammonia nitrogen adsorption.
- Response surface methodology was successfully applied to define model and optimize SMA.

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ABSTRACT

The effect of pig manure, rice straw and clay residue concentrations, as well as their interactive effects on specific methanogenic activity (SMA) at mesophilic and thermophilic conditions were investigated in this work. A central composite design and the response surface methodology (RSM) were applied for designing the anaerobic co-digestion experiments, in order to optimize conditions to enhance methane production. The results showed a significant interaction among the substrates and an enhancement of the methane production and SMA response caused by the three components. The clay residues had a positive effect to reduce the inhibition of SMA caused by high concentration of pig manure due to the ammonia nitrogen adsorbent properties of clay demonstrated in this study by the Freundlich isotherm analysis. Thus, it was corroborated the positive effect of clay as inorganic additive for stimulating pig manure anaerobic digestion. The optimum condition for mesophilic anaerobic co-digestion of pig manure, rice straw and clay mixture was obtained for SMA values of 1.31 and 1.38 gCH_4-COD $gVSS^{-1}$ d^{-1} at mesophilic and thermophilic conditions, respectively. The optimization of the SMA using RSM made possible to identify the substrate interaction effects in a concentration range with a reduced number of experiments. Besides, the model validation proved to be useful for defining optimal combination of wastes considering their anaerobic co-digestion. SMA was also a good response variable for that purpose.

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1. Introduction

The co-digestion of different wastes may improve nutrient balance and cause synergy effects, overcoming substrate deficits [1]. Moreover, this type of waste management may improve methane yield and increase the efficient use of equipment by processing different waste streams in a single facility. The co-digestion of manure and industrial organic wastes has been widespread in Europe [2] and reports on industrial applications of this concept have been published [3–9].

Manures are an abundant source of organic material that can be used as feedstock in anaerobic digesters [10,11]. However, manures often contain concentrations of ammonia greater than necessary for microbial growth, what may inhibit the anaerobic digestion [12,13]. On such cases, the anaerobic digestion of pig manure could be enhanced using agriculture wastes as

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