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The effect of pH control and 'hydraulic flush' on hydrolysis and Volatile Fatty Acids (VFA) production and profile in anaerobic leach bed reactors digesting a high solids content substrate

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HIGHLIGHTS

- ▶ pH control and hydraulic flush improved anaerobic leach bed reactors' performance.
- ▶ pH control improved hydrolysis and VFA production.
- ▶ Neutral pH produced butyric and Acetic acid; Acetic acid was inhibited at low pH.
- ▶ Hydraulic flush enhanced solids degradation and VFA production.
- ▶ Hydraulic flush caused cellulolytic microbes wash out; pH control counteracted this.

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ABSTRACT

The effect of hydraulic flush and pH control on hydrolysis, Volatile Fatty Acids (VFA) production and profile in anaerobic leach bed reactors was investigated for the first time. Six reactors were operated under different regimes for two consecutive batches of 28 days each. Buffering at pH ~6.5 improved hydrolysis (Volatile Solid (VS) degradation) and VFA production by ~50%. Butyric and acetic acid were dominant when reactors were buffered, while only butyric acid was produced at low pH. Hydraulic flush enhanced VS degradation and VFA production by ~15% and ~32%, respectively. Most Probable Number (MPN) of cellulolytic microorganisms indicated a wash out when hydraulic flush was applied, but pH control helped to counteract this. The highest VS degradation (~89%), VFA yield (0.84 kg COD kg^{-1} VS$_{added}$) and theoretical methane potential (0.37 m^3 CH$_4$ kg^{-1} VS$_{added}$) were obtained when pH control and hydraulic flush were applied, and therefore, these conditions are recommended.

1. Introduction

Biogas formed during anaerobic digestion is one of the 'cleanest' biofuels and can be produced from a wide range of substrates, including wastes and crops, having a minimum impact in the environment (Lehtomäki and Björnsson, 2006). Maize (*Zea mays*) has been widely used in Central Europe as an energy crop in recent years (Hopfner-Sixt and Amon, 2007) and is a similar substrate to some agricultural and food wastes since it is rich in cellulose as well as sugars and starch (Cysneiros et al., 2008).

Anaerobic digestion is a complex process in which organic matter is transformed to methane through different steps: hydrolysis, acidification, acetogenesis and methanogenesis (Gujer and Zehnder, 1983). These steps are performed by different groups of microorganisms which have different requirements for growth such as pH, substrate concentration and nutrients concentrations.

To optimise the process, one approach is physically to separate the phases of anaerobic digestion in two reactors, the first for hydrolysis and acidification and the second one for methanogenesis. In this case, the solid substrate is fed into the first stage reactor and the leachate containing the intermediate compounds, mainly Volatile Fatty Acids (VFAs), is continuously removed and fed into the second stage methanogenic reactor. In this way the conditions of each phase can be optimised independently (Ghosh and Klass, 1978) and intermediate compounds such as VFAs, which can be inhibitory to the microbial groups in high concentrations (Viéitez and Ghosh, 1999), can constantly be washed out of the first stage reactor in the 'hydraulic flush' (the removal of leachate from the

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