Potential of high-frequency ultrasounds to improve sludge anaerobic conversion and surfactants removal at different food/inoculum ratio

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HIGHLIGHTS

- Novel application of high frequency ultrasounds as sludge pre-treatment is proposed.
- Effect of food/inoculum (F/I) ratio was assessed by batch anaerobic digestion tests.
- First order kinetic evidenced decreasing trend of hydrolysis rate by increasing F/I.
- Ultrasounds improved specific biogas production, particularly at low F/I.
- F/I affected the anionic surfactants removal and the homologues degradation pathway.

ABSTRACT

High-frequency ultrasounds have recently gained interest as oxidative technique for sonochemical degradation of organic contaminants in water. In this study an innovative approach applying 200 kHz ultrasounds to improve both sludge anaerobic biodegradability and decontamination is proposed. Digestion tests were performed on batch reactors fed either with untreated or sonicated sludge, at different food/inoculum (F/I) ratio, in the range 0.3–0.9. First order kinetic highlighted a decreasing trend of the hydrolysis rate by increasing F/I, both for untreated and sonicated sludge. Positive effect of ultrasounds on specific biogas production was evident, but the conversion rate for pretreated sludge was strongly affected by F/I, and decreased by increasing F/I. Anionic surfactants anaerobic removal occurred in all tests, but the effect of ultrasounds was significant only at F/I = 0.3. By pretreating sludge with high frequency ultrasounds, low F/I was the ideal ratio improving both sludge anaerobic digestion and decontamination.

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1. Introduction

Biosolids land application is nowadays considered the best environmental and economic option to reduce the sludge volume requiring disposal on landfill. In order to produce suitable biosolids, advanced sludge treatments have to (a) reduce sludge volume and mass, (b) remove putrescible and degradable materials, avoiding odour generation, and (c) eliminate pathogens. Among treatment options, anaerobic digestion represents a widely applied biological technology for stabilizing sludge, also because the biogas produced during the digestion process is a clean and environmentally friendly fuel.

One of the crucial factors affecting anaerobic digestion of organic solids is the selection of the food/inoculum ratio as well as the assessment of anaerobic biodegradability of sludge (Neves et al., 2004).

The food to inoculum ratio (F/I) is expressed as the amount of feedstock volatile solids (VS) added per the amount of inoculum VS (Liu et al., 2009). Although this ratio could theoretically affect only the kinetics, and not the ultimate methane yield (which depends only on the organic matter content), it is widely reported that too high F/I may be toxic while too low F/I could prevent enzyme induction for biodegradation (Neves et al., 2004; Prashanth et al., 2006). According to Neves et al. (2004) a substrate to inoculum (S/I) ratio ranging between 0.5 gVS/gVS and 2.3 gVS/gVS could prevent volatile fatty acids accumulation and instability of the anaerobic process. Further studies (Liu et al., 2009) showed that the biogas yield was inversely related to the S/I ratio in the range 1.6–5.0.

Nevertheless, the biogas yields for the anaerobic digestion of solid wastes, as sewage sludge, are generally low because of the