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ENHANCED ANAEROBIC DIGESTION PERFORMANCES: EFFECT OF SLUDGE ULTRASOUND PRE-TREATMENT AND ROLE OF THE MICROBIAL POPULATION DYNAMICS

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Abstract

The biorefinery approach involves multi-step processes in which the first step typically involves biomass pre-treating to render it more amenable for further conversion steps. After the pretreatment, the components of the biomass are subject to biological and/or chemical processing, striving for energy and/or material recovery.
The anaerobic digestion of sludge is an efficient and sustainable technology to stabilize sludge by means of mass and pathogen reduction, and in particular, energy recovery in the form of biogas.
In this work ultrasound pretreatment aims to convert biomass as waste activated sludge, in which the particulate organics are recalcitrant to anaerobic bacterial hydrolysis, into a soluble, more biodegradable form. Anaerobic digestion occurs by the sequential co-operative action of a number of different bacterial trophic groups. Thus, the performance of an anaerobic digestion process is primarily linked to the structure of the microbial community present in the system.
A deeper knowledge of the identity and function of the microbial components would allow to better control the biological processes, in particular in the case of sonicated sludge digestion, improving biogas recovery.
Objective of this study was to evaluate the dynamics of the microbial population (estimated by Fluorescence in situ hybridization, FISH), during batch anaerobic digestion of either raw or sonicated waste activated sludge, at different food/inoculum ratio, comparing the performances of the "classical" 20 kHz ultrasounds with the new frequency of 200 kHz. The potential of the ultrasound pretreatment on the anaerobic digestion process was assessed by volatile solids (VS) degradation and biogas production, too. The positive effect of the high frequency ultrasound pretreatment was more evident for the low-inoculum digestion with a +35% increase of the VS degradation with respect to the +13% obtained from the test at higher inoculum fraction.
The amount of *Archaea* increased over digestion time irrespective of F/I and of sonication treatment. The higher amount of *Archaea* at high inoculum content was most likely linked to the already established methanogenesis process occurring under these conditions, according to the high biogas production of F/I=0.5 digestion, where the gain due to sonication was up to 40%. Two predominant archaeal populations were identified: long *Methanosaetaceae* filaments, and cocci organised in sarcine, identified as *Methanosarcina* spp. The simultaneous presence of these genera suggests a metabolism mainly acetotrophic, whereas the entire set of experiments suggests a strict association of *Methanosarcina* dominance in the structure of anaerobic biomass to an efficient biogas production.