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An Experimental Study on the Effects of Oxygen in Bio-gasification – Part 2 (Extended Abstract)

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1. Introduction

The positive overall impact of limited aeration in anaerobic digestion was demonstrated in a previous experimental study, described in the Part 1 of this paper using batch and semi-continuously fed bioreactors. It has been shown that aeration is less advantageous in the semi-continuous mode compared to the batch feeding mode. The maximum aeration level showing a definite positive effect on methane generation was found to be 1.5 % (as % of feed COD), under the complete mixed semi-continuous mode.

The basic aim of the study described here was to further investigate the observed negative impacts in semi-continuous mode at increased aeration conditions. To accomplish this objective, a larger volume bioreactor (total working volume of 5.5 L) facilitating extensive sampling, was operated for a longer duration (120+ days), compared to the experimental set-up used in the first study (described in Part 1) where the limited reactor volume and operational time hindered more comprehensive analysis of the reactor dynamics.

2. Methodology

A laboratory scale bioreactor (5.5 L working volume) was operated for more than 120 days duration at 35 ^{o}C under the organic loading rate of 0.33 kg COD/m^3.d and the hydraulic retention time of 33 days. Different oxygenation conditions of 0, 2.5, 5.0 and 10.1 %, induced by daily air injection after daily feeding, were tested during the course of the experiment.

3. Results

Oxygenation, under operating conditions tested here, reduced the methane generation with only a trifling effect on total biogas generation since CO_2 production increased. The accumulation of volatile fatty acids is extensively reduced by oxygen introduction, significantly improving the digester stability. Reduction of soluble COD, VFAs and CH_4/CO_2 ratio with increased aeration, and the immediate increase of CH_4 content upon reducing the aeration level imply that the main effect of the added oxygen is enhanced aerobic respiration activity of facultative biomass present in the reactor.

4. Discussion

Simultaneous maintenance of both aerobic and anaerobic activities in a single bioreactor is demonstrated in this study. Methanogenic activity was sustained with no notable prolonged inhibition under the presence of oxygen in a suspended biomass system.

Any increased level of hydrolytic products by aeration, as suggested before (Part 1 of this paper), could have been undermined by faster aerobic respiration in the presence of increased levels of oxygen, leading to the reduced methane production observed.

Considerably reduced soluble organic matter, observed due to the introduction of aeration, represent an enhanced effluent quality and an efficient treatment scheme for waste treatment. Aeration can also aid in producing a more stable and aesthetically sound (odourless - less H_2S and VFAs) and safer (reduced pathogens) biological sludge compared to a complete anaerobic process.

5. Conclusions

Under the operating conditions tested here aeration levels of 2.5, 5.0 and 10.1 % resulted in reduced methane generation proportional to the amounts of oxygen supplied. The total volumetric biogas generation was not significantly influenced by the aeration as reduced methane yield was replaced by increased CO_2 yield.

The observed behaviour of the digester can be explained by aerobic respiration on soluble intermediate products.

Aeration has a significant impact on reducing the VFAs accumulation in the reactor, leading to a more stable digester operation.

Partial aeration assisted anaerobic digestion can be applied as a useful mean for enhanced waste treatment and safer biological sludge utilisation.