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An Experimental Study on the Effects of Oxygen in Bio-gasification - Part 1 (Extended Abstract)

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1. Introduction

Only a limited number of studies have been carried out on investigating the true nature of oxygen involvement in anaerobic bio-gasification. Most of the operating anaerobic digesters are, however, subjected to different levels of limited and unintended aeration effects caused by the various interactions between the digesters and the open environment. This article describes an experimental attempt to explore the impacts of limited aeration on methane potential in anaerobic digestion systems.

2. Methodology

Performances of four different semi-continuously fed bio-reactors, and two series of miniaturised batch mode bio-reactors, operated at 35 ^{o}C temperature under different aeration conditions, are observed and compared based on product formation versus aeration levels.

3. Results

Two series of batch experiments clearly indicated an increasing methane yield in the range of oxygenation loads of 0 – 16 % (% O_2 of COD input). In the semi continuous feed mode, four completely mixed bioreactors operated under the oxygenation levels of 0, 1.3, 2.6 and 3.9 % produced biogas at approximately equal level and constant rates. The methane generation rate at the low oxygenation level of 1.3 % was higher than the strict anaerobic condition, while higher oxygenation levels induced increasingly negative impact on methane production. The positive effect of oxygen on methane production has a much larger range in the batch feed mode compared to the semi-continuous feed mode.

4. Discussion

Aeration can enhance the hydrolysis stage of anaerobic digestion, through increased solubilisation of particulate organic matter, giving rise to the improved digestion performances observed in the batch test series as well as in the 1.3 % O_2 loaded semi-continuous reactor. Increased aeration in semi-continues reactors may, however, have partially inhibited the strict anaerobic organisms and also oxidised the substrate to CO_2, reducing the methane yield as observed in the 3.9 % O_2 fed reactor.

The batch feed condition evidently utilises oxygen in a more beneficial manner than in the case of semi-continuous reactors since much higher oxygen loads give increased methane yields. The batch reactors can be interpreted as performing a sequential aerobic - anaerobic process assuming that all free oxygen is consumed quickly. The same effect can be obtained in full scale operation by staged bioreactors with oxygen enhanced hydrolysis first and subsequent fermentation and methanogenesis.

This study signifies the usefulness of providing a controlled amount of air in an anaerobic digestion process involving particulate organic matter.

5. Conclusions

Under batch feed condition, oxygenation (0 – 16 %) in anaerobic digestion lead to enhanced methane yield apparently caused by the improved solubilisation of substrate matter. Increasing oxygenation however reduced the CH_4/CO_2 ratio due to the significant increase in CO_2 production.

Level of oxygenation within the experimented range (0 ~ 4 % O_2) does not affect the volumetric biogas generation of the semi-continuous feed reactors under the specified operating conditions.

Batch operation conditions can utilise an extended range of oxygen loads more favourably for methane production, compared to the semi-continuous feed operation tested. A staged continuously fed process can be designed to enhance substrate conversion to methane by aeration in the first stage with down-stream methane production.