Investigation on Stability of Dry Anaerobic Flow Reactors Treating Lignocellulose Biomass

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ABSTRACT

Anaerobic co-digestion is a prominent and environmentally friendly technology in agricultural, domestic and industrial bio waste management. It is the most economical and effective method for treating animal waste bedded with lignocellulosic agriculture waste as anaerobic co-digestion of lignocellulosic waste with animal manure proceeds effective C/N ratio and regular nutrient supply mainly from manure in fact it is enriched with different types of nutrients. Lignocellulosic structures are mainly consisted of carbon and hydrogen which resulted in creating lower operating pH values via acidification during its hydrolysis phase. All intermediary steps in digestion process coexist with each other. Thus, an inhibition in a single step can directly affects the entire operation. Main inhibitory substances in AD are undissociated VFA and Free Ammonia Nitrogen (FAN). The main objective in the research is to increase pH by improving buffer capacity via facilitating alkaline and nitrogenous compounds into the system to reduce undissociated VFA concentration. Conversely, use acclimatizing feeding technique to increase the tolerance against FAN inhibition. Experiments were conducted in two reactor configurations namely Plug flow reactor (PFR) and Semi batch reactor (SBR). As continuous mixing in high solid digestion process reported instabilities at high OLRs, performance of the semi batch reactor was investigated at different mixing conditions. Cattle manure was collected from a farm in Carcassonne France. In order to facilitate substantial alkalinity for proper buffering capacity, inoculum was prepared by mixing granular sludge with digestate obtained from a pilot scale anaerobic batch reactor which treated chicken manure bedded with straw. In order to facilitate step wise increase in ammonia concentration, weekly OLR was started from 0.71gVS/L.d and increased gradually by 20% each week. Both systems were continuously monitored by measuring relevant parameters. In SBR, Optimum specific methane yield (SMY) and specific methane production rate (SMPR) were achieved at OLR of 3.07gVS/L.d. and 3.69gVS/L.d. respectively. They were 0.170NLCH_4/g.VS and 4.08NLCH_4/L.d. In PFR, optimum SMY and SMPR were achieved at OLR of 5.35gVS/L.d. They were 0.197NLCH_4/g.VS and 7.37NLCH_4/L.d respectively. Better results were obtained in PFR with compared to past investigations mainly due to higher withstand ability for VFA and FAN inhibitions. PFR can be

recommended to utilize for treating cow manure co-digested with different substrates which include higher biodegradable organic content with lower lignocellulosic content such as fruit and vegetable waste under given acclimatizing feeding technique. SBR should be operated with lower mixing intensities.

Keywords: Anaerobic digestion, Nitrogen inhibition, Reactor stability, Acclimatization, Animal manure, Lignocellulosic feedstocks, Optimization.

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LIST OF ABBREVIATIONS

APHA – American Public Health Association

AD – Anaerobic Digestion

ACD – Anaerobic Co-digestion

COD – Chemical Oxygen Demand

C/N – Carbon to Nitrogen ratio

CSTR – Continues Stirred Tank Reactor

SBR – Semi Batch Reactor

FAN – Free Ammonia Nitrogen

HRT – Hydraulic Retention Time

MSW – Municipal Solid Waste

OLR – Organic Loading Rate

PFR – Plug Flow Reactor

pKa – Acidic Strength

TAN – Total Ammonia Nitrogen

TCOD – Total Chemical Oxygen Demand

TOC – Total Organic Carbon

TON – Total Organic Nitrogen

TS – Total Solids

UASB – Up flow Anaerobic Sludge Blanket

VFA – Volatile Fatty Acids

VS – Volatile Solids

LIST OF ANNEXURES

Annexure 1: Liquid: Solid ratio in the digestate effluent } (liquid : solid ratio) ~ $e^{(a+b\times TS)}$

a and b are constants. TS corresponds to the total solid content in the digestate effluent sample.