Comparative study of OLR and HRT in different reactors and substrates for Biogas production

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***Abstract*— Organic Loading Rate (OLR) is a parameter that indicates how many kilograms of organic dry solids are loaded per meter cube of digester volume and unit of time. HRT is the relation of reactor volume and the volume of daily feed that represents the average time the raw materials spend in the biogas digester. The longer the HRT, the more of the organic matter is degraded. Hydraulic Retention Time (HRT) and OLR affect the biogas process. OLR is the quantity of organic matter to be treated in a specific process at a given time and is related to HRT. All biogas process have a threshold Organic Loading Rate above which it cannot be increased due to either technical limitations that high Total Solids (TS) for the plant design results in inefficient mixing and blockages or microbiological limitations with high Volatile Solids (VS) in feed resulting in intermediate inhibition. The paper compares the OLR and HRT of different reactors using different substrates for Biogas Production.**

***Index Terms*— OLR, HRT, Biogas, Total Solids, Volatile Solids**

I. INTRODUCTION

Anaerobic digestion is the biological degradation of inorganic and organic substrates in the absence of oxygen. Biogas can be used for cooking, steam heating and generation of electricity [1][2][3]. There are four stages involved in the production of biogas using anaerobic digestion process. First, the polymers are converted into monomers from particulate organic matters by undergoing hydrolysis by extra cellular enzymes. Secondly by acidogenic bacteria, that converts the soluble organic matter and products of hydrolysis into organic acids, alcohols, hydrogen and carbon dioxide. Thirdly, conversion of acidogenic products into acetic acid, hydrogen and carbon dioxide by acetogenic bacteria occurs. Finally, methanogenic bacteria are responsible for methane production from the products of acetogens.

The effluent produced from biogas digester can be used as a biofertiliser or soil conditioner [4]. Vegetable wastes generated largely in markets were disposed in municipal landfill or dumping sites [5]. In canning Industry, the waste waters have a high organic content or have little or no toxic material [6] and include the situation where waste waters are produced over a short period of the year. Decanter cake is an agro-industry waste from palm oil mill industry. It was estimated to be 0.27 million tons a year [7]. Biogas production by anaerobic digestion is studied in different fruit and vegetable wastes in a Continuously Stirred Tank Reactor (CSTR) [8]. The high-rate anaerobic reactors developed and used in recent years is the Upflow Anaerobic Sludge Blanket (UASB) reactor which has become one of the most popular designs for the biological treatment of effluents. It is used in particularly in the food processing industries [9].

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II. CSTR FOR FROZEN SEAFOOD WASTEWATER

Thaniya Kaosol and Narumol Sohgrathok, 2012 have stated that anaerobic co-digestion using decanter cake from palm oil mill industry by conducting experiments in laboratory-scale. This will improve the biogas production from frozen seafood wastewater in CSTR (Continuously Stirred Tank Reactor). A mechanical Mixer is used with 24 hours of mixing time where a suitable Hydraulic Retention Time (HRT) was observed in CSTR experiments. The efficiency of biogas production is influenced by the HRT of CSTR process. The best performance for biogas production for this process is 20 days of HRT of anaerobic codigestion with maximum methane production rate of 1.86 l/d. The average maximum methane production is 64.6%. The results show that the decanter cake can improve biogas productivity of frozen seafood wastewater.

III. UASB BIOREACTOR FOR CANNING FACTORY EFFLUENT

W Trnovec and TJ Britz, 1998 demonstrated that in canning Industry, for the treatment of a carbohydrate rich effluent a mesophylic laboratory scale Upflow Anaerobic Sludge Blanket (UASB) bioreactor is utilized. The system had stabilized in the bioreactor with inoculation of 500 g of anaerobic granules and the Hydraulic Retention Time (HRT) was set at 24 h. The substrate pH is set at 8.0 to prevent the effect of rapid acidification. The experimental study is conducted in three steps, first the COD was increased from 2300 to a full strength of 4000 mg/litre. In the second, the OLR was increased by decreasing HRT from 24 h to 8 h which resulted in OLR to increase from 3.95 to 10.95 kg COD m^{-3} d^{-1} with an average COD removal of 90- 93% and removal rate of 9.8 kg COD m^{-3} d^{-1}.

This has concluded that the system had reached its minimum HRT confirming the stabilization of the granule bed and thus HRT of 10 h was taken as the optimum. As the neutralization costs are influencing the economic aspects, lower pH values was investigated in the third study. The pH of the canning effluent was lowered from 8.0 to 5.0 where at this point, COD removal dropped, biogas production decreased and the digester effluent pH is dropped to 6.2. The lower end of the operational pH had been reached from the slow recovery of the digester and the low COD removal ie., 66.1%, any further

lowering of the substrate pH would lead to system failure. At pH 5.5 the fresh canning effluent can be introduced into the digester without any neutralization process.

IV. FED-BATCH REACTOR FOR ANAEROBIC DIGESTION OF VEGETABLE WASTES

B. Velmurugan and R. Alwar Ramanujam, 2001 stated that using the Vegetable wastes like Banana stem, Cabbage and Ladies finger can be anaerobically digested in a fed-batch laboratory scale reactor at mesophilic conditions ie., 35^{o} C Temperature. The OLR was maintained at 2.25 g/l.d with HRT of 30 days. The average methane content in the biogas was 65% and the Methane yield was 0.387 l CH4/g VS added for the selected types of wastes in a single stage fed-batch anaerobic reactor for biogas production. The comparisons of the different substrates utilized for various reactors with influence of OLR and HRT with substrate pH is shown in Table1.

Table 1: Different substrate shows OLR, HRT and pH for different reactors

S.NO	REACTOR	SUBSTRATE/WASTE	OLR	HRT	pH	References
1.	CSTR	Seafood waste water	---*	20 days	7.26	[10]
2.	UASB	Canning industry effluents	between 9.8 and 10.95 kg COD m^{-3} d^{-1}	10 h	5.5	[11]
3.	Fed Batch Laboratory scale reactor	Vegetable waste	2.25 g/l.d.	30 days	5.75	[12]

* OLR studies of Thaniya Kaosol and Narumol Sohgrathok, 2012 for CSTR using seafood waste water is not demonstrated.

V. CONCLUSION

The effect of HRT on the biogas production using CSTR experiment demonstrated that the suitable HRT for anaerobic co-digestion is 20 days with the average maximum methane production at 64.6%. Anaerobic co-digestion of decanter cake from palm oil industry helps in increase in biogas productivity of frozen seafood wastewater from frozen seafood industry and is very important for corporate economy of the biogas plant. UASB reactor is feasible for treatment of the carbohydrate-rich effluents produced in the canning industry. UASB design is operated at HRT of 10 h. The UASB bioreactor in terms of HRTs, OLRs and substrate pH as operated in this study was more efficient when compared to other results. Using Fed batch laboratory scale reactor, the methane content in the reactor was 65% which is approximately same with CSTR using frozen sea food waste water. The Anaerobic digestion of vegetable waste has been carried out in a laboratory scale reactor with a HRT of 30 days.

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