Effect of co-digestion on the lipid inhibition in anaerobic digestion of desiccated coconut wastewater

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ABSTRACT - Seven anaerobic batch reactors were run varying the Desiccated Coconut wastewater (DC) to Food Waste (FW) ratio at room temperature and the daily gas production and CH_4 content was determined. Mono digestion of DC wastewater with a lipid concentration of 1600 mg/L showed significant lipid inhibition. All the co-digestion experiments resulted in enhanced biogas production. The highest methane percentage of 78.19% was obtained in the reactor with the DC:FW ratio of 3:2. The results suggest that the application of co-digestion effectively overcome the lipid inhibition in the anaerobic digestion of desiccated coconut wastewater with an enhanced methane production.
Keywords: Anaerobic digestion; Lipid inhibition; Co-digestion; Desiccated coconut wastewater; Food waste

INTRODUCTION

Lipid rich wastewater has been found to be an excellent substrate for anaerobic digestion considering its high biomethane potential (BMP). In the hydrolysis step of anaerobic digestion, lipids break down into glycerol and free fatty acids in a fast step by the catalytic action of extracellular lipases produced by acidogenic bacteria. Long-Chain Fatty Acids so produced, adsorb on to the cell walls and are then transported into the cells where they are degraded into acetic acid and hydrogen by syntrophic acetogenic bacteria via a process called β oxidation.

Although Long chain fatty acids can degrade according to the aforementioned β oxidation mechanism, they have found to be inhibitory for the anaerobic digestion even at low concentrations (Cho et al., 2012). Since LCFAs easily adsorb on to the microbial cell walls a limitation to mass transfer occurs. The inhibitory effects of LCFAs are not limited to the hindrance in methane production. There are other adverse effects as well. The accumulation of LCFAs which occurs as a result of the fast hydrolysis of lipids compared to the rate-limiting β oxidation causes for an accumulation of sludge and due to the lower density of LCFAs, sludge floatation occurs and consequently biomass washout can also take place.

There are various strategies followed to overcome lipid inhibition like the addition of organophosphates, thermal pretreatment, enzymatic pretreatment, sonification, co-digestion etc.

The desiccated coconut industry is one of the sources through which lipid-rich wastewater is generated. In contrast to the various lipid-rich wastewater widely researched in the literature, the physiochemical characteristics of desiccated coconut wastewater are considerably different. According to Samarasiri et al., (2015), the fatty acid profile of desiccated coconut wastewater is ~55% of medium-chain saturated fatty acid, ~35% of long-chain saturated fatty acids and ~10% of long-chain unsaturated fatty acids. In fact, Lauric acid followed by Myristic acid have the two highest concentrations. Many researches published under co-digestion are focused on synthetic wastewater which is a mixture of two or three types of oils. The effect of Co-digestion to mitigate the lipid inhibition in anaerobic digestion of desiccated coconut wastewater has not been studied.

METHODOLOGY

Sampling

Desiccated coconut wastewater was collected from a separation tank after the oil traps, from a local desiccated coconut plant. The inoculum was obtained from a working UASB reactor at Ceylon Cold Stores plant, Ranala. All the samples were stored under 4°C temperature.

Preparation of Food Waste

100g of rice and vegetables were blended in a general blender for 5mins after mixing with 500ml of water. After mixing another 500ml of water was added and mixed for 3mins. Then the mixture was filtered using a 40mesh general-purpose sieve. The filtrate was used as FW for further steps. All the collected samples were characterized prior to the experiments.

Experimental setup

Seven glass type batch reactors were fabricated. 50ml of inoculum was added into every reactor. The total volume of the reactor was 100ml. Graduated syringes were connected to reactor outlets which measure the daily gas production. Reactor 6,7 were used as the control apparatus.

Table 9. Reactor arrangements and volumes

Reactor No	DC volume (ml)	FW volume (ml)	Distilled water volume (ml)	Total volume (ml)
1	0	50	0	100
2	10	40	0	100
3	20	30	0	100
4	25	25	0	100
5	30	20	0	100
6	10	0	40	100
7	25	0	25	100

Daily biogas production was observed by piston displacement and all readings were noted down. In addition, syringe protocol method was followed to determine the CH_4 content in biogas. After running 7 reactors continuously for 20 days, treated wastewater was obtained after filtering the samples at reactors using

20µm pore size filter papers. Reactor samples were characterized before and after the experiments.

RESULTS AND DISCUSSION

Characterization of DC, FW and Inoculum

Characterization results of DC wastewater align with the values obtained by Samarasiri et al., (2016).

Table 2. Characterization of DC, FW and inoculum

Sample / Parameter	Inoculum	Desiccated Coconut Wastewater	Food waste
pH	6.71 ± 0.032	4.73 ± 0.034	5.2 ± 0.3
tCOD (mg/L)	13128.21 ± 81.6	6564.103 ± 304.23	13948.72 ± 423.52
TS (mg/L)	27353.58 ± 708	5501.222 ± 130	11302.70 ± 352.21
TVS (mg/L)	18652.79 ± 833	3921.855 ± 156	9864.59 ± 98.26
Oil and Grease (mg/L)	ND	1850	ND

Characterization of Reactor Samples

Table 3. Characterization of reactor samples

Parameter / Reactor	Initial pH	Initial COD	Final COD	Final pH
R1	6.71 ± 0.60	13948.72 ± 352.1	1333.34 ± 48.2	7.12
R2	6.85 ± 0.43	12471.79 ± 265.5	1777.78 ± 39.5	7.56
R3	6.58 ± 0.68	10994.87 ± 235.5	888.89 ± 25.6	8.84
R4	7.4 ± 0.65	10256.41 ± 236.6	1333.34 ± 34.7	7.48
R5	7.5 ± 0.71	9517.95 ± 135.5	889.89 ± 15.62	7.45
R6	6.93 ± 0.58	1312.82 ± 26.82	378.24 ± 25.2	7.23
R7	7.2 ± 0.42	3282.05 ± 53.36	2537.36 ± 65.7	7.33

Biogas Production

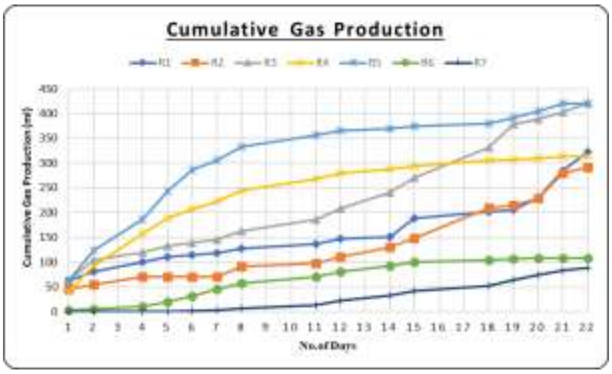

Figure 1. Cumulative gas production

Reactor (R3) with the co-substrates mixed to the ratio of 2:3 (DC:FW) was observed to give the maximum total gas production of 422 mL which is followed by the reactor (R5) with DC:FW ratio of 3:2 which is 420 ml.

COD Reduction

Reactor (R3) with the DC:FW ratio of 2:3 was observed to provide the best COD reduction of 91.92% which is closely followed by that of the reactor (R5) with DC: FW ratio of 3:2 which is 90.66 %. Very low COD reduction in the reactor (R7) where desiccated coconut wastewater is mono-digested can be explained by the high degree of lipid inhibition in the reactor.

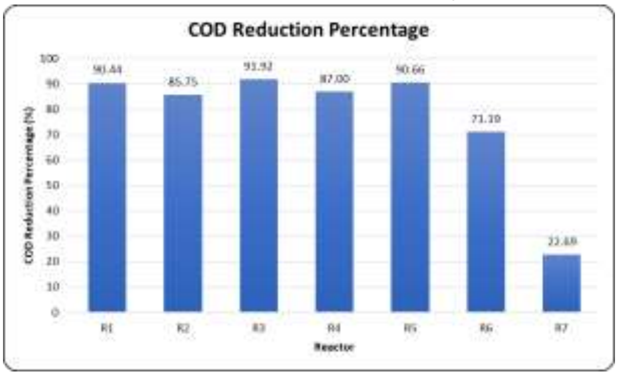

Figure 2. COD reduction percentages by rectors

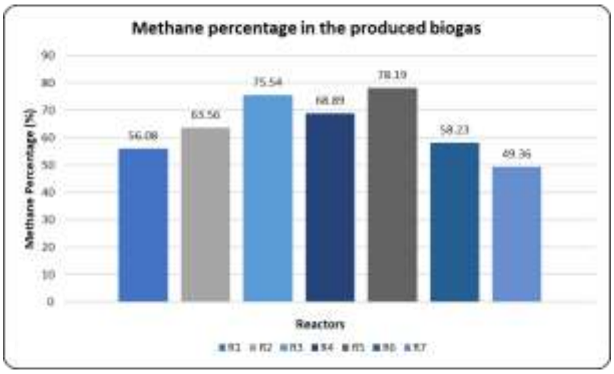

Figure 3. Methane percentage in the produced biogas

R5 reactor showed 4.72 times higher biogas production than the inhibited rector R7. R5 also showed the highest methane content of 78.19 % in the produced biogas compared to the 75.53% methane produced in the R3 reactor.

CONCLUSIONS

The anaerobic digestion process of desiccated coconut wastewater is inhibited when the lipid concentration exceeds 1600 mg/L. Maximum total biogas production could be obtained when using DC:FW ratio was 2:3. However, a biogas production closer to the maximum could be obtained using DC:FW ratio of 3:2 with the highest methane percentage. Hence, the results suggest that the lipid inhibition that occurred in the mono-digestion of desiccated coconut wastewater can be effectively overcome by carrying out co-digestion with food waste and an enhanced methane yield can be obtained. The optimum DC:FW ratio can be concluded as 3:2.

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