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ANAEROBIC PALM OIL MILL EFFLUENT TREATMENT USING A THERMOPHILIC SLUDGE FROM THE EFFLUENT

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Abstract
A mixed culture sludge of a mesophilic pond palm oil mill effluent was used for thermophlic anaerobic treatment of palm oil mill effluent in a batch fermenter. The cultivation was carried out successfully while being monitored. The cultivated thermophilic mixed culture could reduce at least 80% of Chemical Oxygen Demand (COD) in palm oil effluent with a mixed liquor suspended solid concentration of 20,000mg/L after 10 days operation producing biogas with average 75% methane.

Introduction

Ponds of waste-water generated from palm oil effluent are features commonly encounter in localities in the Eastern zone of Nigeria, where palm oil processing are dominant. More often than none, the waste-water generated in the milling activities are conventionally discarded into digged pits which eventually develop into full-fledged ponds or open digesting pits (Ma et al, 2003). These no doubt constitute an environmental nuisance and its consequences among the populace. Hence, the call for the introduction of anaerobic bioreactors for the replacement of the traditional means of disposal of the effluent.

Anaerobic bioreactor has been proved to possess the capacity of producing better treated effluent quality devoid of pollution of any kind and with a high volume biogas production capacity (Poh and Chong, 2009).

Nevertheless, the anaerobic thermophilic seed innoculant is not readily available. Several studies showed that a cultivated mixed microbial consortium for the treatment of a targeted waste-water can be obtained by acclimatizing the existing seed sludge from any biological

sludge basin with the targeted waste-water as the substrate. Sreekanth et al (2009) obtained an inoculum specifically for pharmaceutical waste-water treatment by utilizing slaughter house waste sludge as the seed source and allowed the sludge to be acclimatized to the system by feeding pharmaceutical waste-water as the substrate. Similarly, Tan and Ji (2010) also utilized sludge from oil contaminated waste-water treatment as the seed source to obtain a carbazol-degrading microbial consortium by feeding carbazol-containing waste-water as the substrate.

In this study likewise, the anaerobic mesophilic sludge of the palm oil mill effluent was acclimated with the substrate and temperature expected in the bioreactor. That is to say that the mesophilic sludge mixed culture was tailored for thermophilic anaerobic palm oil mill effluent treatment.

Materials and Methods

The infors HT, Switzerland 2 litres batch fermenter was used for the cultivation of the mixed culture for palm oil mill effluent at thermophilic condition. The bioreactor was inoculated with 0.8L of seed sludge and 1.0L of palm oil mill effluent. The pH of the fermeneter was adjusted to 7.0 with 1M sodium hydroxide. Sodium bicarbonate was further added to provide alkalinity to the vsystem, and to maintain the mixture at a pH of 7.0. Nitrogen gas was used to purge oxygen from the fermenter. Stirring speed of the fermenter was fixed at 200 rpm. The temperature of the fermenter was firstly set at 35^{o}C for 6 hours before a single step increase of temperature to 60^{o}C to allow the adaptation of mesophilic seed sludge. This was in accordance to study by Phaik Eong Poh et al, (2010). In his study, he found that one step temperature increase provided a shorter start-up period as compared to a step-wise increase approach. An adapted population of mixed culture was obtained when the effluent Chemical Oxygen Demand (COD) remained constant with little or no variation (Ji et al, 2009).

Seed Sludge Material

The seed sludge material for the cultivation of mixed culture was collected from the bottom dept of palm oil mill effluent pond (Umuani, Amaji-Umuabi, Udi LGA, Enugu State, Nigeria).

Substrate for Mixed Culture Cultivation

Palm oil mill effluent was used as substrate for the cultivation of the mixed culture. The palm oil mill effluent was collected from palm oil mill effluent pond, Amaji – Umuabi, Udi LGA, Enugu State Nigeria. Table 1 shows the average characteristics of the palm oil mill effluent used:

Table 1: Average Characteristics of palm oil mill effluent used for the cultivation of thermophilic mixed culture

Parameters	Chemical Oxygen Demand (COD)	Soluble Chemical Oxygen Demand (SCOD)	Suspended Solids (SS)
Mg/L	**20,0000**	**8,250**	**6,315**

Steady-State Fermenter Operation

The treated palm oil mill effluent in the fermeneter was withdrawn and replace with new feed when at least 80 – 90% of COD has been degraded from the effluent. The chemical oxygen demand, soluble chemical oxygen demand and suspended solids concentrations of the treated palm oil mill effluent were measured according to AHPA standard methods (Eaton et al, 2005). Biogas volume was measured using a method by which deflated poly vinyl chloride balloon was fitted over the opening of the fermenter. Biogas production was indicated by a gradual inflation of the balloon. The deflated balloon was measured as Ag. Then, upon production of biogas, the balloon was unfixed and measured as Bg. The difference Cg was regarded as the volume of the biogas generated from the fermenter, while the biogas composition was measured with Handheld GFM, 416 series biogas analyzer.

Result and Discussion

The effect of pH on the COD removal efficiency of mesophilic mixed culture in a batch fermenter is highly dependent on the pH of the system during start-up process. During the first 7 days of start-up, the removal of COD from the system increased steadily to 50% until the pH of the system reduced from 7.6 to neutral. Here, the COD removal efficiency was found to decline thereafter. As the pH of the fermenter dropped less than pH 7, buffer solution ($NaHCO_3$) was to be dosed into the system to maintain it at a pH 7, to keep at least 60% COD efficiency removal. In the Run 2, operation, similar observation was obtained, that is where dosing of buffer was required as the methanogens were not quick enough to convert acetic acid to methane.

While in the subsequent runs (3, 4, 5, 6 – 9), the pH of the fermenter was maintained with the optimum operating pH range (6.6 – 7.6) without the dosing of alkaline buffer. The pH rise in the system indicates that the methanogens have adapted to the system (Phaik Eong Poh et al, 2010) and is able to proceed to the steady state evaluation of the mixed culture. Under the thermophilic condition, biogas production was evaluated simultaneously under Run 6 – 9. Seed sludge was added into the system and the feed volume of palm oil mill effluent was reduced to increase the mixed liquor suspended solid concentration. The volume of seed sludge and palm oil mill effluent in the batch fermeneter for each steady-

state runs were indicated in table 2. The HRT required to reduce more than 90% of COD of palm oil mill effluent was reduced from 20 days (Run 5) during cultivation period to less than 9 days (Run 6 – 9) during steady-state period. This no doubt shows that a mixed culture consisting of thermophilic microbes were successfully cultivated as the culture showed much improvement in terms of COD removal efficiency and biogas production.

Table 2: Average Characteristics of Palm Oil Mill Effluent for the Cultivation of Thermophilic Mixed Culture

Feed Condition				
Run	6	7	8	9
HRT / Days	7	6	6	7
Ph	5.28	4.29	4.33	4.20
COD (mg/l)	27500	30,425	40,350	48,420
SCOD (mg/l)	12,750	17,240	22,150	22,150
SS(mg/l)	5820	7220	92250	84340
Operating Conditions				
Run	6	7	8	9
Temperature ^{o}C	55	55	55	55
OLR (kg COD/m^3day	1.41	1.74	1.89	0.94
Feed Volume (ml)	800	700	600	900
Seed Sluge -Vol(ml)	700	800	900	900
Treated Effluent Condition				
Run	6	7	8	9
pH	7.30	7.18	7.12	7.22
COD Removal Efficiency (%)	80	85	90	80
SCOD Removal Efficiency (%)	79	80	80	78
SS Removal Efficiency (%)	70	75	60	52

Methane Concentration (%)	70	65	69	66

Conclusion

In the anaerobic treatment of palm oil mill effluent at thermophilic condition was successfully in view of the fact that the mixed culture was able to reduce up to 80% of COD in palm oil mill effluent after 6 days of operation. While the average methane concentration in the biogas produced was 75%.

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