POME TREATMENT UTILIZING HIGH RATE HYBRID ANAEROBIC REACTOR

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SUMMARY: A study was conducted on the performance of a 50 litres upflow hybrid anaerobic digester in treating Palm Oil Mill Effluent (POME) which is noted for its high strength nature. The bacterial growth film on the PVC rings in the digester enables the reduction of the hydraulic retention times and the elimination of the sludge recycling process. The digester was operated at an average temperature of 30°C with an average COD loading rate of 5.2 kg/m^3/d. The digester reduces about 40 of TS, 62% of COD, 70% of VS as well as 90% and 95% of VSS and SS respectively. The SS reduction in the hybrid digester is the highest compared to a few other treatment techniques.

Key Words: Anaerobic Digestion, Hybrid Reactor, Biofilter, POME Treatment.

INTRODUCTION

In 1981 Malaysia produced about 2.8 million tonnes of palm oil and its palm oil export constituted about 80% of the world total (LEONG 1982). The palm oil production increased to 4.54 million tonnes in 1986 (ANON 1987).

In 1981 alone the palm oil industry produced about 7.5 million tonnes of Palm Oil Mill Effluent (POME) and it is estimated to reach 15 million tonnes by 1990 (LEONG 1982). Table 1 shows the typical characteristics of POME. Various treatment methods which are mainly the anaerobic tank digestion, the ponding system and the combination of both have been employed. The high suspended solids content and chemical oxygen demand (COD) value deem anaerobic digestion as an appropriate treatment process. LESLIE GRADY JR and KIM (1980) recommended the use of anaerobic digestion for wasteswater exceeding 4000 mg/L COD value. Anaerobic process can be simplified to consist of acidification and methanogenation phases. Two groups of bacteria, the acetogens and methanogens are responsible for the degradation of waste under acidic and close to neutrality conditions respectively. The slow forming methanogens are however the sensitive controlling factor in the process.

A study was conducted in the laboratory employing an upflow hybrid reactor to treat POME, known for its high strength nature. Hybrid digester as an alternative treatment process is rather new among the available anaerobic technology. It combines both the conventional unit and the bacteria support media with the aim of reducing the processing time. Settlement and degradation occur in the conventional section and the soluble organic being converted to inorganics mostly within the bacterial film of the media. The film formation eliminates the need for long hydraulic retention time and/or the sludge recycling procedure.

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Table 1: Typical POME Characteristics (MA *et al.* 1982).

Parameter	Range	Mean
pH	3.8 - 4.5	4.1
BOD	10250 - 47500	25000
COD	15550 - 106360	53630
TS	11450 - 164950	43635
SS	410 - 60360	19020
VS	8670 - 154720	36515
NH^3-N	0 - 110	35

All units in mg/L except pH

This paper intends to discuss the performance of a 50 litres hybrid reactor loaded with high strength POME and compares its performance with a few different processes studied at laboratory scale and those in current practice.

MATERIALS AND METHODS

The digester being utilized in the study is of square cross section constructed of perspex and equipped with several ports for gas collection, desludging and monitoring probes besides the inlet and outlet ports. Poly Vinly Chloride (PVC) rings of 1 inch diameter and 1 inch length acting as the bacterial support media rested on perforated perspex sheet which isolates the free space compartment, typical of a conventional reactor. A sludge compartment at the bottom is incorporated in the design to avoid the reduction of the effective digestion volume during operation. The digester has a total effective volume of 50 litres with a porosity of 0.85 in the filter media compartment. The filter compartment constitutes two third of the overall effective volume. Figure 1 shows the layout of the unit process schematically.

The digester is designed to operate at 10 days hydraulic retention time but with 6.8 days in the filter compartment. Maximum design COD loading rate is limited to 6 kg COD/m^3/d although there are reactors with loading rates reaching 15 kg COD/m^3/d (SWITZENBAUM 1983).

Seeding of the reactor was initially done with a mixture of digested POME and cowdung mixed liquor. The reactor was fed in batches with cowdung mixed liquor at the earlier phase and later with POME only.

The digester was operated at an ambient temperature of about 30°C within the mesophilic range at an average loading rate of 5.2 kg COR/m^3/d. Table 2 shows the corresponding loading parameters, besides the COD and these are total solids (TS), suspended solids (SS), volatile solids (VS) and volatile suspended solids (VSS). Initially pH, and later volatile acids and alkalinity were monitored as indicators to the system performance. All analyses were according to Standard Methods (APHA 1985). Gas production was also monitored by a simple water displacement method.

RESULT AND DISCUSSION

Figure 2 shows the control parameters namely pH values, alkalinity and volatile acids concentrations during the digestion period. pH is seen to be within the range of

Figure 1: Schematic diagram of hybrid anaerobic system.

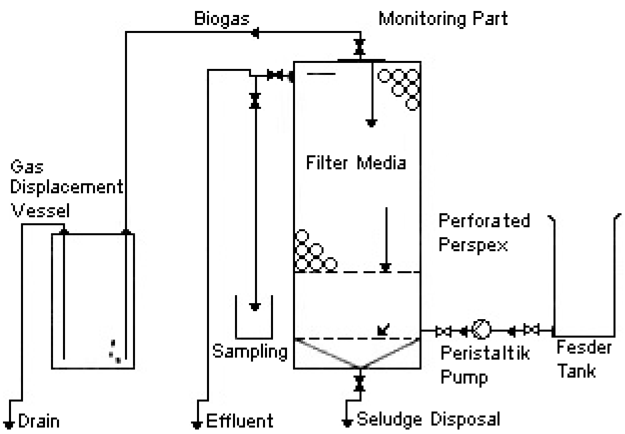

Table 2: Various corresponding parameter loading rates on hybrid anaerobic reactor.

Parameter	Average Influent (mg/L)	Average Loading Rate (kg/m^3/d)
TS	46720	4.7
VS	39680	4.0
SS	16250	1.6
VSS	14230	1.4
COD	52150	5.3

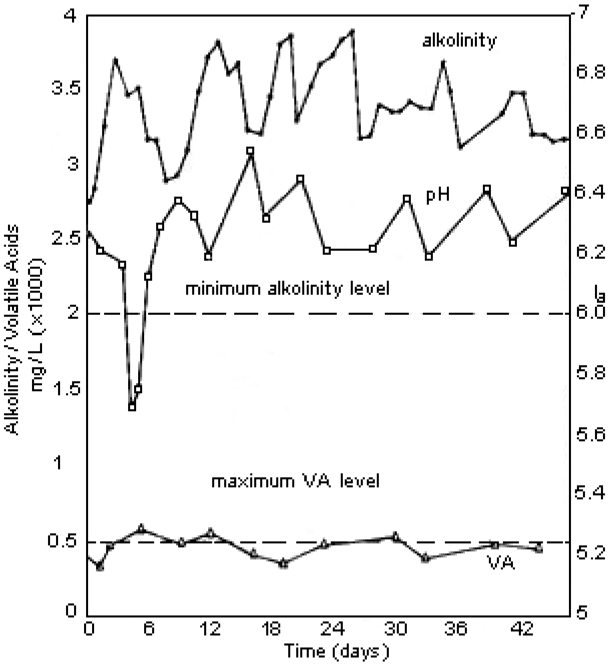

Figure 2: Alkalinit, pH and volatile acids with respect to time.

6.5 and 6.8 whereas the alkalinity level is distinctly above the 2000 mg/L as $CaCO_3$, i.e., the lower limit for effective anaerobic digestion process. The volatile acid is however close to the maximum limit of 500 mg/L which if exceeded will lower the digestion efficiency and later lead to souring of the digester. Thus for this digestion period the control parameters are within the recommended range for anaerobic digestion process.

Figure 3 to 7 show the reduction of various parameters, i.e., TS, VS, SS, VSS and COD under 10 days hydraulic retention time. Table 3 summarizes the average reduction. Total solids reduction of about 40% was achieved and volatile solids of about 30% escapes the

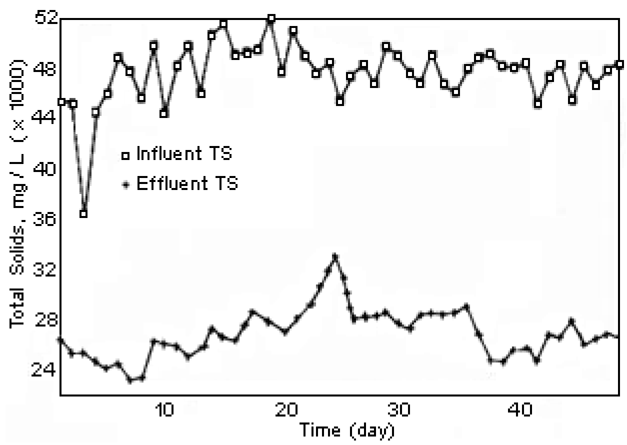

Figure 3: Variation of influent and effluent total solids with respect to digestion time.

Figure 3: Summary of various parameters reduction in hybrid anaerobic reactor.

	Influent (mg/L)		Effluent (mg/L)		Reduction
	Range	Mean	Range	Mean	(%)
TS	36440-51900	46720	23220-39390	28680	40
VS	30250-43370	39680	8060-14530	11770	70
SS	12300-18380	16250	210-2000	760	95
VSS	10830-16240	14230	1010-2420	1400	90
COD	42520-58510	52150	16540-26620	20100	62

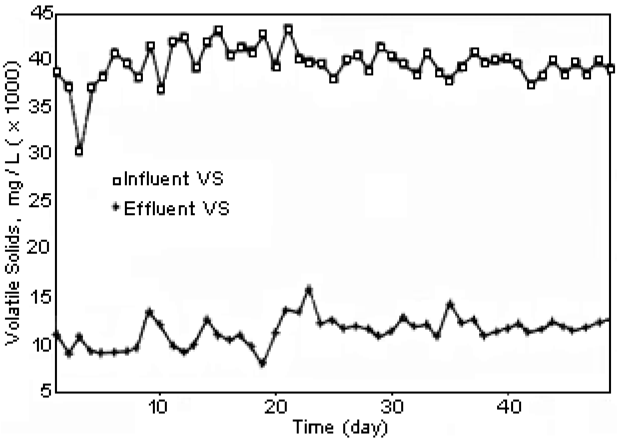

Figure 4: Variation of influent and effluent volatile solids with respect to digestion time.

digestion. These conform with the low COD reduction of just above 60%. However the reduction in suspended and volatile suspended solids of over 90% were achieved. The process is thus suitable for reducing was tewater with a high suspended solids content effectively, which in this case takes place at on average SS loading rate of 1.63 kg/m^3/d within a short retention time. COD reduction is rather low and this could be attributed to the short retention time of 6.8 days in the filter compartment which is inadequate for maximum conversion of the soluble solids.

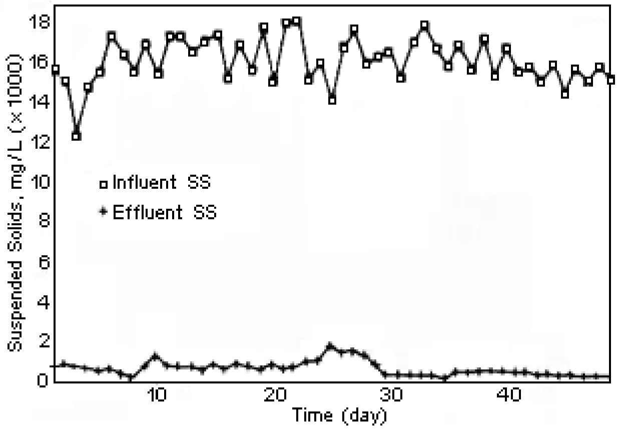

Figure 5: Variation of influent and effluent suspended solids with respect to digestion time.

Table 4 compares the various process alternatives utilizing POME as feed material with their corresponding reduction values. Process number 3 which is the hybrid reactor being studied shows the best suspended solids reduction but rather low in COD reduction compared to the anaerobic tank digestion (number 1) and the anaerobic biofilter (number 2). As mentioned earlier this is possibly due to inadequate reaction time. However it excels the pond system with 52 days hydraulic retention time in all aspects. The anaerobic biofilter with higher specific surface area due to smaller media size and lower COD loading rate reduces COD value better than the hybrid at the same total retention time. According to TANTICHAROEN *et al.* (1986) a 4 litres upflow anaerobic filter of similar media size as in anaerobic biofilter, fed with tapioca waste at COD loading of 1.7 kg/m^3 and 11 days retention time achieved 84% reduction in COD. Thus it can be seen that given a larger specific surface area for bacterial growth or

Table 4: Comparison of various anaerobic process performance in treating POME.

	1	2	3	4
Reactor Volume (m^3)	3600	0.03	0.05	-
Filter Media Surface Area (sq. M/cu.M)	-	400	185	-
Vol of Media Compartment	-	40	40	-
COD Loading Rate (kg/m^3/d)	1.1	3.9	5.3	-
Hydraulic Retention Time (d)	22.5	10	10	52
COD Reduction (%)	80	75	62	54
TS Reduction (%)	74	-	40	61
SS Reduction (%)	85	85	95	49
VS Reduction (%)	-	-	70	76
VSS Reduction	-	-	90	-

1: Anaerobic tank with recyling ratio of 1:1, 2: Anaerobic biofilter utilizing 1/2" diameter PVC media (upflow), 3: Hybrid anaerobic reactor utilizing 1" diameter PVC media (upflow), 4: Anaerobic ponds (2 d acidification, 30 d primary and 20 d secondary ponds)

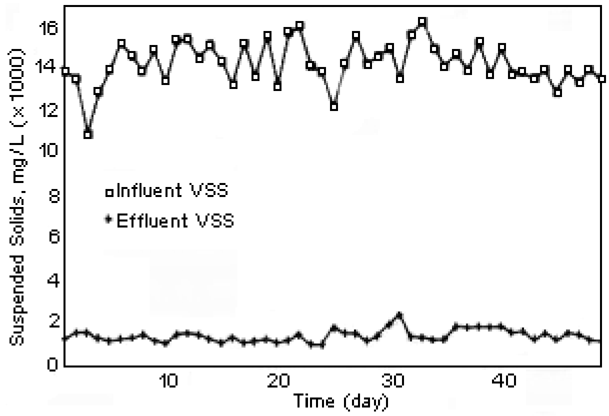

Figure 6: Variation of influent and effluent volatile suspende soils with respect to digestion time.

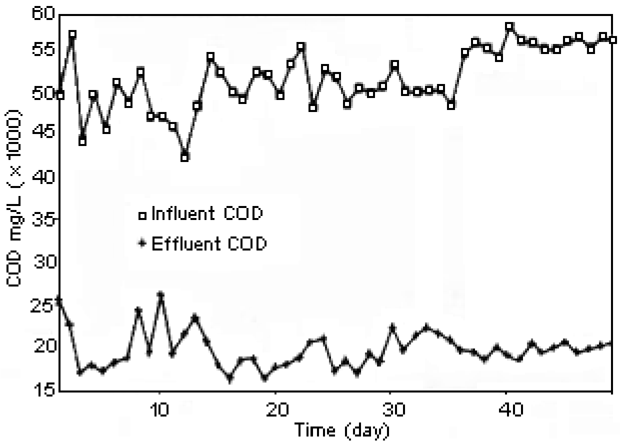

Figure 7: Variation of influent and effluent chemical oxygen demand with respect to digestion time.

longer retention time within the media or lower loading rate, or a combination there of a better reduction can be achieved.

Theoretically the design hydraulic retention time is 10 days. Assuming the bulk of the effluent that enters the process leaves 10 days later, the relationship between effluent concentration and gas production can be arrived at by comparing the gas production with 10 days lag on the effluent concentration as shown in Figure 8. The high COD values are seen to associate with low gas production.

CONCLUSION

The hybrid reactor gave a high reduction in suspended solids content of greater than 90% with a high COD loading rate but a low COD reduction i.e. 60%. However with a much higher surface area for bacterial growth, the reactor will be able to achieve high COD reduction even at a rather high COD loading and short retention time. Thus the hybrid reactor is suitable for treating wastewater with high suspended solids which is typical of POME.

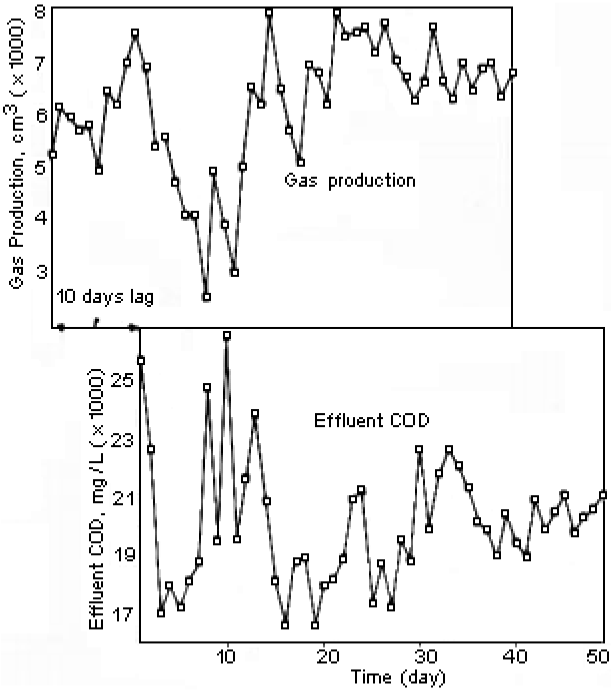

Figure 8: Variation of gas production and effluend COD with respect to digestion time.

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