Palm Oil Mill Effluent Treatment Using Rotating Biological Contactor

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ABSTRACT

A study was conducted to treat palm oil mill effluent (POME) using a pilot scale anaerobic-aerobic rotating biological contactor (RBC). A two-stage RBC system was set up in the Environmental Engineering Laboratory at Universiti Teknologi Malaysia (UTM). The anaerobic RBC was utilised as the primary treatment unit and the effluent was further treated using an aerobic RBC. The main aims of this project were to start up the RBC system, to monitor the anaerobic and aerobic system and to investigate the ability of the unit to treat POME. After full acclimatisation, continuous flow through the system exhibited reduction efficiencies of 96%, 71% and 80% for BOD_5, COD and SS respectively.

INTRODUCTION

The oil palm industry has been and is a very important factor in Malaysia's fast growing economy. In 1990 Malaysia produced about 6.09 million tonnes of crude palm oil contributing to about 10 % of the nation's earnings[1]. Malaysia is currently the world market leader in palm oil production with over 252 palm oil mills and 36 refineries producing crude and refined palm oils respectively. Although the industry is a major revenue earner for the country, it produces a large volume of highly polluting effluents (Table 1). Approximately 15.2 million tonnes of palm oil mill effluent (POME) is generated annually from palm oil mills, with a population equivalence of BOD for 22.3 million people. This is greater than the total population of Malaysia.

In the early days, when the number of mills were small, the mills discharged their effluents into nearby rivers and streams causing severe pollution. It also gives rise to obnoxious odours in the neighbourhoods of the mills, which is a nuisance to passers-by and local residents. Through the enforcement of strict regulations, the government, through the Department of Environment (DOE) managed to bring the situation under control. Over the last two decades, several treatment methods have been successfully employed by the palm oil mills to treat their effluents. These systems include waste stabilisation pond systems (85% of palm oil mills in Malaysia use this system), open tank anaerobic digesters with extended aeration and high rate anaerobic digesters (contact digesters and upward packed reactors have been used). If well operated and maintained, these processes are able to treat POME to the discharge standards stipulated by the DOE (Table 2).

Although these systems have worked very well for a number of years, there are signs that the pond systems are failing due to the lack of desludging practice. Another disadvantage of the pond system is that it takes up a considerable land area. There is therefore a need to explore other technologies to be applied to treat POME that are more efficient and do not occupy a big land area. This study was aimed to investigate the ability of the anaerobic and aerobic rotating biological contactors (RBC) in series to treat POME.

MATERIALS AND METHODS

The full layout of the pilot scale RBC system is shown in Figure 1. The system, made of fibre glass, was bought from Klargester, Aylebury, United Kingdom and consists of a holding tank, anaerobic RBC and aerobic RBC in series. The anaerobic RBC was supplied with a two piece lid moulded from the same material and has a capacity of 2000 litres while the aerobic RBC has a capacity of 350 litres. The media were light plastic biodiscs bonded together and having a crinkled surface enabling easier formation and trapping of biomass. The media was fully submerged in the anaerobic RBC and 40% submerged in the aerobic RBC. The discs were driven by a mains power supply.

For the start-up procedure, the RBC had to be seeded to initiate the trapping process. Aerobic biomass was collected from a facultative pond at Felda Bukit Besar Palm Oil Mill, which is about an hour's drive from the university, and poured over the biodiscs. All samples were taken from the mill. The organic loading rate (OLR) was kept low to enable acclimatisation of the biomass. Throughout the start-up, the RBC system was operated in recycle mode with a flowrate of 2.5 l/min. Full operational capacity was reached after 4 weeks. The biomass had spread to cover the entire disc area with clusters of up to 20 mm thickness forming on the outer edges of the biodiscs.

The RBC was then operated to simulate more realistic conditions if installed at a palm oil mill. Much higher OLR's were used to test the efficiency of the RBC under stressed conditions. The OLR was increased from 4.8 g BOD/m^2.day to 13.6 g BOD/m^2.day with the system operating under continuous flow conditions at 1.4 l/min.

Samples were taken from the holding tank, the anaerobic RBC and the aerobic RBC to enable changes in BOD, COD and SS between each process to be determined. Other parameters namely pH, DO, temperature and flowrate were measured to give a full picture of how the RBC's were behaving. The pH was measured using a portable Hach pH meter. DO was measured using an ORION DO meter which also measures temperature. The flowrate was determined using a measuring cylinder and a stop-watch. BOD, COD and SS were determined in accordance to Standard Methods.[2]

RESULTS AND DISCUSSIONS

Table 3 depicts all operating efficiencies during the final run. BOD reduction efficiencies were remarkably good at more than 96% during full operational mode. The reduction in COD was found to be consistent to values around 160 mg/l. Levels of SS in the final effluent were around 35 mg/l for the operating average.

Although the final effluent produced encouraging results, the anaerobic RBC behaved differently. The pH was found to drop below the desired minimum value of 6.6 implying a possible buildup of volatile fatty acids resulting in methanogenic bacteria ceasing to function. The hydraulic retention time (HRT) was 24 hours, which is low for anaerobic systems. It was quite difficult to increase the HRT due to the limited capacity of the reactor as well as the pumping rate.

For the aerobic RBC, the maximum OLR of 13.6 $gBOD/m^2$.day was found to be higher than the optimum range stipulated by Metcalf and Eddy[3] for secondary process application (3.6 to 9.8 g BOD/m^2.day). However, the hyraulic loading rate (HLR) values ranging from 0.03 to 0.05 m^3/m^2.day was lower than Metcalf and Eddy's 0.08 to 0.16 m^3/m^2.day. The low HLR also resulted in a slightly longer hydraulic retention time (HRT) of abour 4 hours. Biomass thickness corresponded to wastewater substrate levels and following a relatively high OLR, a healthy biomass of 3 to 4 mm thickness was established. SS removal could be improved with proper design of a settling tank before the final discharge.

CONCLUSIONS

High reduction efficiencies of 96%, 71% and 80% in BOD_5, COD and SS respectively were achieved once the biomass was fully established. For a successful treatment of POME, the aerobic RBC should continue to be applied as a secondary process. Staging modifications would be sufficient, whereby a number of anaerobic RBC's could be assigned to each RBC required. Further improvements in effluent quality could undoubtedly be achieved through long-term operation at a palm oil mill. This will ensure a clear knowledge of the efficiency and cost-effectiveness of the the RBC when applied in the oil palm industry.

REFERENCES

[1] Ngan, M.A., A Novel Treatment Process for Palm Oil Mill Effluent, *Palm Oil Research Institute of Malaysia (PORIM),* May 1995, TT No.29, 1995.

[2] American Public Health Association, *Standard Methods for the Examination of Water and Wastewater,* 14th Edition , Washington, 1976.

[3] Metcalf and Eddy Inc., *Wastewater Engineering: Treatment, Disposal, Reuse,* 3rd. Edition, McGraw Hill, New York, pg. 632, 1991.

Table 1 Typical Analysis of POME [1]

Parameter	Range	Mean
BOD (3 day, 30°C)(mg/l)	10200 - 47500	25000
COD (mg/l)	15500-106360	53635
Total Solids (mg/l)	11450-164950	43635
Suspended Solids (mg/l)	410 - 60360	19020
Oil and Grease (mg/l)	130 - 86430	8370
Ammonia Nitrogen (mg/l)	0 - 130	35
Total Nitrogen (mg/l)	-	770
Acidity (pH)	3.8 - 4.5	4.0

Table 2 Parameter Limits For Watercourse Discharge For Palm Oil Mill Effluent [1]

BOD (3day, 30°C) (mg/l)	100
Suspended Solids (mg/l)	400
Oil and Grease (mg/l)	50
Ammoniacal Nitrogen (mg/l)	150
Total Nitrogen (mg/l)	200
pH	5 - 9

Table 3 Operating Efficiencies

BOD (% Reduction)	COD (% Reduction)	SS (% Reduction)
99.5	67.1	98.3
97.4	70.4	85.8
96.3	76.9	78.2
91.7	70.0	78.6

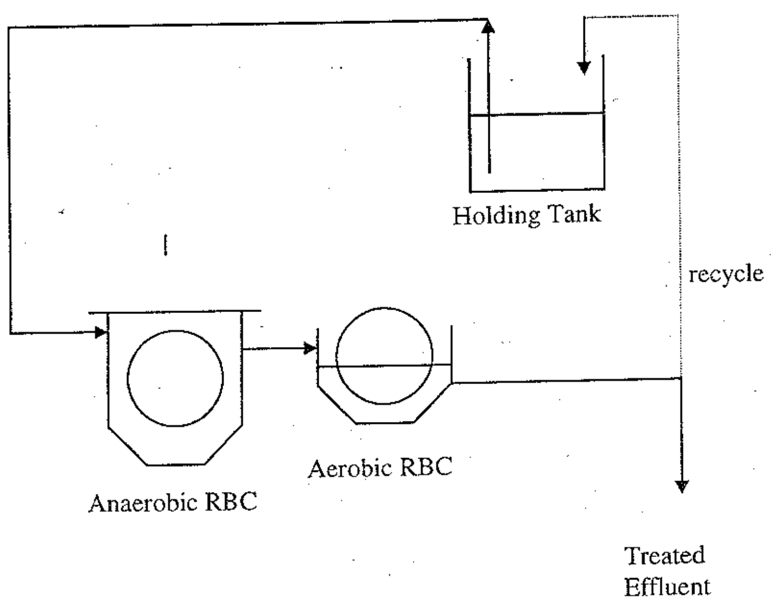

Fig. 1 Schematic Layout