A ZERO DISCHARGE TREATMENT SYSTEM OF PALM OIL MILL EFFLUENT

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Palm oil milling is invariably accompanied by the generation of effluent. Palm oil mill effluent (POME) is a potential environmental pollutant. On average, 1.5 m^3 water is needed to process 1 t of fresh fruit bunches and half of this ends up as POME. Currently, some 85% of POME treatment of more than 400 mills in the country is based on open ponding system, which involves biological treatments of facultative, anaerobic and aerobic degradations. The treated effluent is discharged into a watercourse. Effluent discharged to the environment is closely monitored by the Department of Environment (DOE), in particular the biological oxygen demand (BOD).

While anaerobic digestion and tertiary treatment technologies are able to meet the regulatory discharge requirement of BOD 100 ppm - the current upper limit set by the DOE - existing technologies are generally unable to consistently meet the more stringent discharge standard of BOD 20 ppm.

Generally, palm oil milling is being scrutinised for the potential threat to pollute air, water and soil. Hence, zero effluent discharge is timely. In addition, this type of treatment emits low carbon. A zero effluent discharge system (*Figure 1*) in the palm oil milling process treats the incoming effluent so that the treated effluent is free from impurities, recycles the water and turns the solid waste into fertiliser. Captured biogas is used for electricity generation.

SYSTEM REFERENCE

MPOB in collaboration with Shanghai Jiaotong University (SJTU) and Ronser Bio-Tech Sdn Bhd has developed the technology and built a zero discharge POME treatment pilot plant (*Figure 2*) at MPOB's Palm Oil Mill Technology Centre (POMTEC) in Labu, Negeri Sembilan. The aims of the zero effluent discharge treatment system are to recover usable materials such as oil, sludge, biogas and water from the effluent, to minimise waste and to recover plant nutrients.

Biogas Trapping

Phase 1. Anaerobic digestion at mesophilic temperature of 36°C was able to generate biogas consisting of an average of 68% CH_4, 28% CO_2 and 850 ppm H_2S. *Table 1* shows the performance of the biogas digester – the advanced anaerobic expanded granular sludge bed, AnaEG®. Based on 10 hr operation, AnaEG® produced biogas at a rate of 52.7 m^3 hr^{-1} with a total production of 21-25 m^3 biogas per m^3 POME (based on chemical oxygen demand, COD removal). A desulphurisation system installed using chemical treatment showed ~70% removal of H_2S.

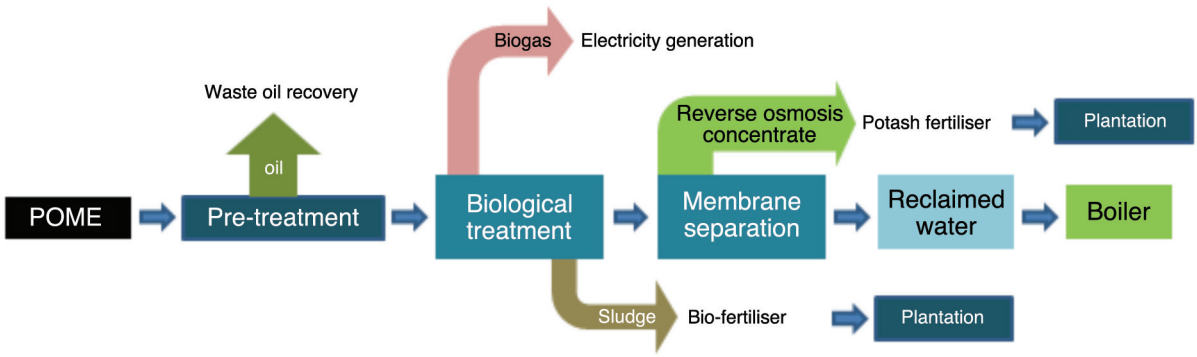

Figure 1. Schematic diagram of a zero discharge process of palm oil mill effluent (POME).

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Figure 2. Zero effluent discharge pilot plant, Labu, Negeri Sembilan.

Phase 2. The one year performance was based on 24 hr monitoring for 12 months (*Table 1*). The digester tanks were able to produce an average of 28 m^3 biogas per m^3 of POME (based on COD removal). The average compositions of biogas were 57% CH_4, 42% CO_2 and 418 ppm H_2S.

ECONOMIC ANALYSIS

Table 2 provides an indication on the economic feasibility of the zero discharge treatment plant and the potential energy production from a typical 60 t hr^{-1} palm oil mill.

TABLE 1. PERFORMANCE OF ANAEROBIC SYSTEM IN BIOGAS PRODUCTION USING ZERO EFFLUENT DISCHARGE TREATMENT AT PALM OIL MILL

Parameters	Unit	Average value	
		Phase 1*	Phase 2**
Plant capacity	m^3 hr^{-1}	5	5
Hydraulic retention time	day	8	8
Biogas generation	m^3 day^{-1}	474.6	1 304.1
Efficiency of biogas production	m^3 biogas hr^{-1}	52.7	144.9
Influent	m^3 day^{-1}	31.4	82.7
Upflow velocity	m hr^{-1}	0.062	0.062
Influent COD	mg $litre^{-1}$	47 914.4	70 743.4
Effluent COD of AnaEG1	mg $litre^{-1}$	2 764.4	4 287.9
Effluent COD of AnaEG2	mg $litre^{-1}$	2 780.0	-
Volumetric loading rate	kg COD m^{-3} day^{-1}	1.642	1.642
COD removal rate	%	93.7	93.9
COD reduction	kg day^{-1}	1 399.0	4 077.1
Efficiency (in POME injection)	m^3 biogas m^{-3} POME	15.31	15.76
Efficiency (in COD reduction)	m^3 biogas kg^{-1} COD	0.34	0.32

Note: * Based on 10-hr operation over a 12-month period (October 2010 to September 2011).
** Based on 24-hr operation over a 12-month period (June 2012 to May 2013).
COD = chemical oxygen demand.
POME = palm oil mill effluent.

Effluent Discharge of Biological Oxygen Demand (BOD) 20 ppm

The advanced bio-contact aerobic tank, BioAX® used for aerobic decomposition of POME was a subsequent process after the AnaEG® anaerobic treatment. Samples of the treated POME were regularly taken at the outlet of the BioAX® for BOD analysis. It was found that the system was capable of achieving 81% compliance for BOD 20 ppm and 97% below BOD 50 ppm.

INTELLECTUAL PROPERTY AND COMMERCIALISATION

- A Patent Cooperation Treaty (PCT) patent application on zero discharge treatment system of palm oil mill effluent (POME) was filed by MPOB and Ronser on 11 May 2012 (PCT Application No. PCT/MY2012/000100).
- MPOB has granted Ronser to commercialise and market the technology.

TABLE 2. ECONOMIC ANALYSIS OF THE ZERO DISCHARGE SYSTEM (for a typical 60 t FFB hr^{-1} palm oil mill)

Material	Production rate/conversion factor	Quantity
Fresh fruit bunches (FFB)	60 t hr^{-1} or 432 000 t yr^{-1}	60 t hr^{-1} or 432 000 t yr^{-1}
Palm oil mill effluent (POME)	@ 65% of FFB processed	39 t hr^{-1} or 39 m^3 hr^{-1}
Biogas (based on COD reduction*)	@ 21 m^3 m^{-3} POME	819 m^3 hr^{-1}
Potential energy from biogas	@ 20 000 kJ m^{-3}	16 380 000 kJ hr^{-1} or 4 550 kJ s^{-1} or 4 550 kW
Power output/size of power plant	@ 30% thermal efficiency	1.4 MW
Potential electricity to the grid	@ 80% utilisation factor x 7200 hr yr^{-1} (300 days x 24 hr)	8 064 000 kWhr yr^{-1}
Potential of electricity sales	@ RM 0.40 $kWhr^{-1}$	RM 3.2 million yr^{-1} or RM 67.2 million/21 yr
Total CAPEX (AnaEG®)	@ RM 7 million MW^{-1}	RM 9.8 million
Total OPEX per year	@ 2.25%/year of CAPEX	RM 220 500 yr^{-1}
Net profit per year	(Annual electricity sales – OPEX)	RM 3.0 million yr^{-1}
Payback period	RM 9.8/3.0	3.3 yr
Total CAPEX (BioAX®)	-	RM 2.0 million

Note: * Intergovernmental Panel on Climate Change (IPCC) default value = 0.25 kg CH_4 kg^{-1} COD
COD = chemical oxygen demand.
CAPEX = capital expenditure.
OPEX = operational expenditure.

For more information, kindly contact:

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