

**Topic:** System analysis for biogas production from palm oil mill effluent at mesophilic and thermophilic conditions

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## **ABSTRACT**

An anaerobic hybrid reactor (AHR) was applied to treat and produce methane from raw palm oil mill effluent (POME) containing high concentrations of chemical oxygen demand (COD), oil and grease (O & G), and suspended solids (SS). AHR, the combination of anaerobic sludge bed and fixed film reactor, contains packed zone and sludge zone in the upper and lower parts of the reactor, respectively. Several influencing factors for the AHR process performance and stability, temperature is one of the major factors to study their effect. Therefore, this research was studied the effects of mesophilic (35°C) and thermophilic (55°C) temperatures on reactor performance, stability and microbial activities. The system analysis was applied in this study for decision making.

Two 6 L of cylindrical AHRs were operated at mesophilic (35 °C) and thermophilic (55 °C) temperature. The AHRs' performance and stability as well as microbial activity through optimization of maximize organic loading rate (OLR) and shortest hydraulic retention time (HRT) were carried out. The initial seed was collected from mesophilic anaerobic treatment system, and acclimatized to 55 °C for thermophilic AHR. Specific glucose utilization (SGU), representing acidogenic activity, was 0.77 and 0.72 gCOD<sub>glucose</sub>/gVSS.d for mesophilic and thermophilic reactors, respectively. Specific methanogenic activity (SMA), representing methanogenic activity, was 0.27 and 0.17 gCOD<sub>methane</sub>/gVSS.d for mesophilic and thermophilic reactors, respectively. In addition, system analysis was used to determine in 3 aspects for financial, environment, and energy.

The AHRs successfully operated within 193 days. The operating condition was step increased from organic loading rate (OLR) 1.2 to 11.5 gCOD/l.d and hydraulic retention time (HRT) was reduced from 20 to 5.3 days. According to the results, it was found that the increasing of OLR and reducing of HRT were affected to the AHRs performance and stability as well as microbial activity, while the operating temperature did not significant affect to the process

performance, process stability and microbial activity. The operating condition at OLR 7.5 gCOD/l.d and HRT 10 days showed the significant reactor performance and stability for the both AHRs. At mesophilic reactor (MR), the reactor performance can achieve at 80% of COD removal, 11 l/d of methane production and 0.30 lCH<sub>4</sub>/gCOD<sub>removed</sub> of methane yield. pH was in the range of 7 – 8 and the ratio of TVA/Alk was lower than 0.5. Acidogenic activity in sludge and packed zones was 2.59 and 2.52 gCOD<sub>glucose</sub>/gVSS.d, respectively. Methanogenic activity in sludge and packed zones was 0.20 and 0.24 gCOD<sub>methane</sub>/gVSS.d, respectively. While at thermophilic reactor (TR), it can reach at 80% of COD removal, 13 l/d of methane production, and 0.34 lCH<sub>4</sub>/gCOD<sub>removed</sub> of methane yield. pH and the ratio of TVA/Alk were in the same values of MR. Microbial activity of acidogens and methanogens in sludge zone was 2.78 gCOD<sub>glucose</sub>/gVSS.d and 0.21 gCOD<sub>methane</sub>/gVSS.d, respectively. Whereas, acidogenic and methanogenic activities in packed zone were 2.01 gCOD<sub>glucose</sub>/gVSS.d and 0.21 gCOD<sub>methane</sub>/gVSS.d, respectively.

The high AHR's performance and stability were obtained at the condition of OLR 7.5 kgCOD/ m<sup>3</sup>.d and HRT 10 days. The system analysis was applied in this operating condition by the assumption for 600 m<sup>3</sup>/d POME generation with COD concentration 75 kgCOD/ m<sup>3</sup>. Installation cost, operating and maintenance cost of mesophilic was lower than thermophilic plants. Profit of thermophilic was higher than mesophilic plants. There are payback periods (PP) was 2 years for both plants, internal rate of return (IRR) were 42% and 45% for mesophilic and thermophilic treatment plants, respectively. Net present value (NPV) was 189 and 208 million baht for mesophilic and thermophilic plants, respectively. The thermophilic treatment plant was recommended to investment, with higher than 10.28% of NPV, 7.4% of energy production and 6.5% of electricity production, than mesophilic treatment plant. The environmental analysis of GHG reduction found that the thermophilic treatment plant was slightly more than mesophilic treatment plant 7.38% of CO<sub>2</sub>e.

**Keyword:** anaerobic hybrid reactor, mesophilic, operating condition, palm oil mill effluent, thermophilic, system analysis