ABSTRAK

Indonesia sebagai salah satu penghasil minyak sawit terbesar di dunia menerima permintaan minyak sawit yang semakin tinggi. Produksi minyak sawit menggunakan 3.44-58.3 m^3 air/ton minyak sawit mentah dan lebih dari 50% air berubah menjadi palm oil mill effluent (POME). POME adalah limbah cair berpolutan tinggi dengan COD lebih dari 50.000 mg sCOD/L, oleh sebab itu perlu dilakukan pengolahan lebih lanjut sebelum dibuang ke lingkungan atau digunakan kembali. Metode yang paling umum digunakan adalah proses anaerob seperti reaktor anaerob *fluidized bed* (AFBR). Akan tetapi, proses anaerob dengan AFBR hanya mampu menurunkan COD hingga berkisar 1000 mg sCOD/L. Proses lanjutan yang dilakukan agar POME dapat dibuang atau digunakan kembali adalah menggunakan proses aerob, yaitu *aerobic granular sludge* (AGS) dalam *sequencing batch reactor* (SBR). Pada studi ini, dilakukan evaluasi performa AGS-SBR dalam pengolahan POME dari efluen AFBR. Target konsentrasi efluen SBR, yaitu dibawah 10 mg sCOD/L. Inokulum yang digunakan dalam AGS-SBR diambil dari proses pengolahan limbah restoran secara aerob yang berada dekat Kali Code, Yogyakarta. Inokulum diaklimatisasi ke dalam SBR dengan limbah sintetis hingga membentuk granul yang stabil. Satu siklus berjalan 6 jam di mana membutuhkan 1 menit pengisian, 59 menit *idle*, 289 menit aerasi, 10 menit pengendapan, dan 1 menit *discharge*. POME yang digunakan divariasikan menjadi konsentrasi 600 mg sCOD/L, 300 mg sCOD/L, dan 100 mg sCOD/L dan menghasilkan efluen dengan sCOD *removal* stabil diatas 75%, N-*removal*, dan P-*removal* yang masih perlu peningkatan lebih lanjut. Parameter fisis seperti SVI dan ukuran granul diukur selama proses dengan SVI di bawah 150 mL/g dan ukuran granul memiliki rentang 200-500 μm. Proses AGS-SBR juga dievaluasi dengan model kinetika pada tiap perlakuan yang menghasilkan μ_{obs} dengan rentang 0.005-0.0015 $hari^{-1}$, Y_{obs} semakin rendah saat konsentrasi tinggi, yaitu 1 g VS/g sCOD; q_{obs} mencapai 0,32 g sCOD/g VS.hari; dan k_d berkisar 0,18-0,31 $hari^{-1}$. Hasil konstanta kinetika tersebut dianalisis menggunakan ANOVA *Single Factor* yang menunjukkan bahwa konsentrasi sCOD dalam umpan hanya signifikan memberikan perbedaan pada $Y_{obs.}$ Nilai Y_{obs} semakin rendah saat konsentrasi tinggi karena semakin banyak yang dikonsumsi untuk pertahanan sel dari keberadaan inhibitor. Dengan melihat sCOD *removal*, *nutrient removal*, dan evaluasi konstanta kinetika, pengolahan POME dengan AGS-SBR sudah cukup baik tetapi masih perlu dilakukan studi lebih lanjut karena POME juga mengandung inhibitor yang tinggi terutama saat konsentrasi tinggi. Selain itu, diperlukan proses lanjutan setelah AGS-SBR untuk mencapai standar baku mutu air kelas IV.

Kata kunci: Kelapa sawit; minyak sawit; POME; Aerobic Granular Sludge; Sequencing Batch Reactor

ABSTRACT

Indonesia is one of the largest palm-oil producing in the world to serve the high demand of palm oil worldwide. Palm oil production consumes 3.44-58.3 m^3 of water/ton crude palm oil and more than 50% of the water becomes liquid waste known as palm oil mill effluent (POME). POME is high-strength wastewater with COD higher than 50,000 mg sCOD/L; therefore, it needs proper treatment before being discharged into the surrounding. The common method to treat POME is anaerobic process such as anaerobic fluidized bed reactor (AFBR). However, AFBR can only lower the COD level to about 1000 mg sCOD/L. Further POME treatment needs to use aerobic process, one of which is aerobic granular sludge (AGS) in sequencing batch reactor (SBR). This study evaluated the performance of the AGS-SBR technology in treating the effluent from the AFBR with the COD concentration of 1000 mg sCOD/L. The target concentration of the SBR effluent is below 10 mg sCOD/L. In this study, the AGS-SBR was started with the inoculum sludge taken from a restaurant wastewater treatment plant in Code River Area, Yogyakarta. The inoculum was acclimatized in the SBR with synthetic wastewater to form stable granules. One SBR cycle took 1 minute of filling, 59 minutes of idling, 289 minutes of aeration, 10 minutes of settling, and 1 minute of discharging. The SBR influent was varied with the concentrations of 600 mg sCOD/L, 300 mg sCOD/L, and 100 mg sCOD/L and all substrate concentration variations produced effluent with stable sCOD removal above 75%. However, N-removal and P-removal still needed further improvement. Physical parameters such as SVI and granule size during the process were reported as SVI below 150 mL/g and granule sizes in the range of 200-500 μm. The AGS-SBR process was well represented by a kinetic model for each treatment which produced μ_{obs} of 0.005-0.0015 day^{-1}; Y_{obs} became lower at higher feed concentration, with the value reached as high as 1 g VS/g sCOD, q_{obs} reached 0.32 g sCOD/g VS.day; and k_d ranged 0.18-0.31 day^{-1}. Kinetic constants were analyzed with ANOVA Single Factor and it revealed that sCOD variations in the feed only significantly affected Y_{obs}. The *Y_{obs} values were lower at high concentrations because a big portion of the feed was consumed for cell maintenance due to the existence of inhibiting factors. Due to the considerable sCOD removal, nutrient removal, and evaluation of kinetic constants, POME treatment with AGS-SBR was quite good but still need further study because POME contains high inhibitors, especially at high concentrations. In addition, further process treatment is needed after AGS-SBR to achieve class IV water quality standards.*

Keywords: *Palm oil; POME; Aerobic Granular Sludge; Sequencing Batch Reactor*