CHARACTERIZATION AND OPTIMIZATION OF THE PERFORMANCE OF AN INTEGRATED ULTRASONIC MEMBRANE ANAEROBIC (IUMAS) IN TREATING POME AS SUBSTRATE

HYBAT SALIH MOHAMED ABDLRHMAN

DOCTOR OF PHILOSOPHY

UNIVERSITI MALAYSIA PAHANG

SUPERVISOR'S DECLARATION

We hereby declare that we have checked this thesis, and, in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Doctor of Philosophy.

PROF. DR. ABDURAHMAN HAMID NOUR
PROFESSOR
COLLEGE OF ENGINEERING
UNIVERSITI MALAYSIA PAHANG
LEBUHRAYA TUN RAZAK
26300 GAMBANG, KUANTAN
TEL : +609-549 2811 FAX : +609-549 2689

(Supervisor's Signature)

Full Name : DR. ABDURAHMAN HAMID NOUR

Position : PROFESSOR

Date : 6/12/2021

(Co-supervisor's Signature)

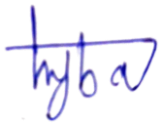
Full Name : DR. ZULKIFLY BIN JEMAAT

Position : SENIOR LECTURER

Date : 6/12/2021

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.



(Student's Signature)

Full Name : HYBAT SALIH MOHAMED ABDLRHMAN

ID Number : PSK17003

Date : 6/12/2021

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ABSTRAK

Efluen kilang minyak kelapa sawit (POME) didapati amat mencemarkan air sisa dengan tingginya nilai keperluan oksigen kimia (COD) dan keperluan oksigen biokimia (BOD), telah menyebabkan pencemaran yang teruk terhadap alam sekitar dan sumber air. Cara tradisi untuk merawat POME adalah merugikan pada kedua-dua perspektif ekonomi dan alam sekitar. Di dalam tesis ini, potensi sistem anaerobik membran ultrasonik bersepadu (IUMAS) telah diperkenalkan dan dikaji. Kerja ini bermula dengan beberapa kajian pencirian untuk memberikan kefahaman terhadap isu-isu asas berkenaan rawatan air sisa. Kajian ini juga menggunakan kadar pemuatan organik yang berbeza daripada 0.5 hingga 13 kg/COD/m^3/d sebagai permulaan kepada sistem, yang beroperasi sebagai semiselanjar pada suhu mesofili pada 25 - 35 °C dan julat tekanan 1.5 - 2 bars. Kecekapan IUMAS keseluruhan telah dinilai di bawah beberapa keadaan mantap dan influen COD pelbagai antara 70,000 to 80,000 mg/L. IUMAS menggambarkan prestasi yang lebih baik berbanding dengan sistem anaerobik membran (MAS) apabila merawat efluen POME, apabila menerima peratusan yang lebih tinggi bagi kecekapan penyingkiran untuk COD, BOD, kekeruhan, dan pepejal terampai total (TSS) iaitu masing-masing sebanyak 97%, 80%, 96% and 98.6%. Peratus gas metana (CH4) tertinggi adalah 84.5%. Pencirian POME dikenalpasti secara kualitatif menggunakan SEM, EDX dan FTIR. Kaedah IUMAS memberikan prestasi yang lebih baik berbanding kaedah MAS. Model kinetik Monod, Contois, Chen dan Hashimoto telah digunakan untuk menganggar prestasi kaedah IUMAS untuk rawatan enap cemar POME dan sistem tersebut telah menunjukkan ramalan yang baik. Didapati Model Chen and Hashimoto telah menunjukkan pemadanan terbaik sebanyak 90%. Satu kajian pengoptimuman untuk penyediaan keadaan parameter optimum terpilih bagi penghasilan gas metana secara maksimum telah diadakan menggunakan Kaedah Ransangan Permukaan (RSM). Faktor penentu seperti pH, kadar pemuatan organic (OLR), COD dan masa retensi hidraulik (HRT) mula ditapis menggunakan pendekatan reka bentuk faktoran 2 tingkat. Kaedah penapisan itu memaparkan kesan parameter yang ditapis adalah ketara. Tambahan lagi, kesan keempat-empat parameter pengoperasian itu dikaji menggunakan reka bentuk pusat pada permukaan. Keputusan tersebut menunjukkan keadaan optimum bagi penghasilan metana tertinggi daripada POME adalah sebanyak 88.7% apabila menggunakan pH, 6.9; OLR, 6.5kg COD/m3/day, COD, 74,000 mg/L, and HRT, 5 hari. Keputusan yang terhasil daripada kajian ini telah membuka keupayaan potensi sistem anaerobik membran ultrasonik bersepadu (IUMAS) dalam merawat air sisa POME.

ABSTRACT

Palm oil mill effluent (POME) is a highly polluting wastewater with high chemical oxygen demand (COD) and biochemical oxygen demand (BOD). These causes severe pollution to the environment, and water resources. Traditional ways of treating POME are disadvantageous from both economic and environmental perspectives. In this Thesis, the potential of an integrated ultrasonic membrane anaerobic system (IUMAS) for the treatment of POME was investigated. The work began with some characterization studies to provide understandings of fundamental issues for wastewater treatment. This research used different organic loading rates from 0.5 to 13 kg/COD/m3/d as a fed to the system, which operated as semi-continuously at mesophilic temperature from 25-35 °C and pressure ranges of 1.5-2 bars. The IUMAS overall efficiency has been evaluated under six steady states and the influent COD varied between 70,000 to 80,000 mg/L. IUMAS depicted better performance as compared to membrane anaerobic system MAS results in treating the palm oil mill effluent, POME as it achieved higher percentage removal efficiencies for COD, BOD, Turbidity and total suspended solids, TSS which are 97%, 80%, 96% and 98.6% respectively. The highest methane gas percentage, CH4 was 84.5%. The POME characterized qualitatively using SEM, EDX and FTIR. IUMAS performed better compared to MAS. Monod, Contois, Chen and Hashimoto kinetics models were used to estimate the performance of IUMAS for POME sludge treatment and the system has shown good prediction and Chen and Hashimoto model has shown the best fittings of 90%. An optimization study for the preparation conditions of the selected optimum parameters for maximum methane gas production was investigated using Response Surface Methodology, RSM. The determining factors such as pH, organic loading rates, OLR, COD, and Hydraulic retention time, HRT were initially screened using 2 level factorial approach. The screening revealed that the effect of screened parameters was significant. Furthermore, the impact of these four operating parameters were investigated using the faced central design techniques. The results presented the optimum conditions for highest methane yield is 88.7% from POME were pH, 6.9; OLR, 6.5kg COD/m3/day, COD, 74,000 mg/L, and HRT, 5 days. The results obtained in this study have exposed the capability of integrated ultrasonic membrane anaerobic system, IUMAS, in treating POME wastewater.

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