THE PERFORMANCE OF INTEGRATED ULTRASONIC MEMBRANE ANAEROBIC SYSTEM (IUMAS) IN TREATING SUGAR CANE WASTEWATER

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DOCTOR OF PHILOSOPHY

UNIVERSITI MALAYSIA PAHANG

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

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ABSTRAK

Efluen kilang tebu (SCME) menyebabkan pencemaran alam sekitar yang teruk kerana kepekatannya yang tinggi dari segi bahan pencemar. Kaedah rawatan konvensional SCME mempunyai kelemahan dari sudut persekitaran dan ekonomi. Sebilangan besar kaedah rawatan menggunakan membran sebagai penyelesaian bagi masalah pencemaran air sisa tetapi mengalami pencemaran membran. Dalam kajian ini, potensi Sistem Membran Anerobik dibantu Ultrasonik Bersepadu (IUMAS) dalam menangani efluen kilang tebu telah dikaji. Penyelidikan ini menggunakan kadar pemuatan organik yang berbeza sebagai bekalan ke sistem, yang beroperasi secara separa berterusan pada suhu mesofilik 30°C hingga 35°C dan julat tekanan 1.5-2 bar. Tujuh keadaan mantap telah dicapai sebagai sebahagian daripada kajian kinetik yang menggunakan julat kepekatan antara 6000 mg / L hingga 25000 mg / L bagi pepejal terampai cecair campuran (MLSS). Tujuannya adalah untuk mendapatkan keadaan operasi yang optimum dan penghasilan metana yang maksimum serta membandingkan prestasi IUMAS dengan sistem anaerobik membran (MAS) dalam merawat SCME. IUMAS menunjukkan prestasi yang lebih baik berbanding MAS dalam merawat efluen kilang tebu (SCME) kerana ianya mencapai kecekapan peratusan penyinkiran yang lebih tinggi bagi COD, BOD, kekeruhan dan TSS yang masing-masing adalah 96.12%, 67%, 94.3% dan 98.8%. Peratusan metana yang tertinggi adalah 80.9% berbanding MAS pada 77.3%. Pencirian SCME dijalankan untuk menyiasat jenis bakteria yang menghasilkan gas metana dan memberikan rawatan terbaik bagi kecekapan penyingkiran menggunakan pendekatan analisis yang berbeza seperti SEM / EDX, dan FTIR. Persamaan kinetik daripada Monod, Contois dan Chena dan Hashimoto digunakan dalam UMAS untuk memerihalkan ilmu kinetik SCME. Pekali korelasi adalah pada 54% bagi model Monod, 85% bagi model Contois dan 91% bagi model Chen dan Hashimoto. Dari yang tertinggi, penyesuaian R^2 yang paling terbaik didapati pada Monod. Pekali hasil pertumbuhan Y dan kadar kerosakan mikroorganisma spesifik b masing-masing didapati pada 0.931 g VSS/g COD dan 0.0214 hari^{-1}. Kajian pengoptimuman untuk keadaan penyediaan parameter-parameter terpilih yang optimum bagi penghasilan gas metana yang tertinggi disiasat menggunakan Kaedah Tindakbalas Permukaan (RSM). Faktor penentu seperti pH, OLR, COD, dan HRT pada mulanya disaring menggunakan pendekatan faktorial 2 peringkat. Pemeriksaan menunjukkan bahawa pengaruh parameter-parameter di atas adalah signifikan. Selanjutnya, kesan bagi keempat-empat parameter operasi ini disiasat menggunakan teknik reka bentuk komposit berpusat (CCD). Hasil kajian menunjukkan keadaan optimum bagi hasil metana dari SCME adalah pH 7.1, OLR 8kg COD/m^3/hari, COD HRT 5.65 hari dengan CH_4 84.7%. Hasil yang diperoleh dalam kajian ini telah mendedahkan kebolehan sistem memberan anaerobik berbantu ultrasonik (IUMAS) dalam merawat air sisa SCME. Thus, this method can be a promising source for treating all industrial wastewater.

ABSTRACT

Sugarcane mill effluent (SCME) causes severe environmental pollution due to its high concentration in term of pollutants. Conventional methods of treating SCME have disadvantages from both environmental and economic perspectives. Most of the treatment methods used the membrane as a solution to wastewater pollution problems but suffering from membrane fouling. In this study, the potentials of Integrated Ultrasonic Assisted Membrane Anaerobic System (IUMAS) in treating sugarcane mill effluent was investigated. In this research different organic loading rates were used as a fed to the system, which operated semi-continuously at mesophilic temperature 30°C to 35°C and pressure ranges of 1.5–2 bars. Seven steady states were accomplished as a part of a kinetic study that considered concentration ranges of 2500 mg/L to 6000 mg/L for mixed liquor suspended solids (MLSS). The aim was to obtain optimum operating conditions and maximum methane production as well as the performance of IUMAS comparing with membrane anaerobic system (MAS) in treating SCME. IUMAS depicted better performance as compared to MAS in treating the sugarcane mill effluent (SCME) as it achieved higher percentage removal efficiencies for COD, BOD, turbidity and TSS which were 96.12%, 67%, 94%and 98.8%, respectively. While higher percentage removal efficiencies for MAS were 93.8%, 66.3%, 73.8% and 97.4%. The highest methane percentage was 80.9 % for IUMAS compared with MAS was 77.3%. The SCME characterized to investigate by using a different analytical approach such as SEM/EDX, and FTIR. SEM morphology analysis for IUMAS, the permeate flux for the membrane filtration of SCME increased while for MAS decreased the permeate flux due to fouling problem. For FTIR in both methods obtained 5 identified peaks before treatment. However, after treatment indicated 6 and 5 identified peaks for IUMAS and MAS. Kinetic equations from Monod, Contois and Chen and Hashimoto were employed used IUMAS to describe the kinetics of SCME treatment. The correlation coefficient was 54% for Monod, 85% for Contois model and 91% for Chen and Hashimoto model. From the highest, R^2 the best fitting in Chen and Hashimoto model. The growth yield coefficient Y and the specific microorganism decay rate b were determined as 0.23 g VSS/g COD and 0.0214 day^{-1} respectively. An optimization study for the preparation conditions of the selected optimum parameters for maximum methane gas was investigated using Response Surface Methodology (RSM). The determining factors such as pH, OLR, COD, and HRT were initially screened using 2 level factorial approach. The screening revealed that the effect of the above parameters was significant. Furthermore, the impact of these four operating parameters were investigated using the central composite design (CCD) techniques. The results presented the optimum conditions for methane yield from SCME were pH 7.1, OLR 8 kg COD/m^3/day, COD HRT 5.65 day with CH_4 84.7%. The results obtained in this study have exposed the capability of ultrasonic-assisted membrane anaerobic system (IUMAS) in treating SCME wastewater. Thus, this method can be a promising source for treating all industrial wastewater.

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