PERFORMANCE OF COAGULATION, ADSORPTION, ULTRAFILTRATION AND HYBRID TREATMENT SYSTEM ON KAOLIN/HUMIC ACID REMOVAL

LOW AIK QI

MASTER OF SCIENCE

UNIVERSITI MALAYSIA PAHANG

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Master of Science

_____

(Supervisor's Signature)

Full Name :

Position :

Date :

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 : LOW AIK QI

ID Number : MKE 15004

Date : 5 October 2018

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LOW AIK QI

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ABSTRAK

Proses rawatan air konvensional yang sedia ada tidak dapat memenuhi kualiti air minuman. Penggunaan bahan kimia dalam proses rawatan akan menjejaskan kualiti air kerana ia menghasilkan produk sampingan. Selaras dengan ini, penyelidikan ini bertujuan untuk mengurangkan penggunaan bahan kimia dalam proses pengentalan, maka proses hibrid atau proses gabungan telah dinilai dalam projek penyelidikan ini. Larutan kaolin dan asid humik telah digunakan sebagai bahan ketidaktulenen yang biasanya didapati dalam sumber air semulajadi dan proses rawatan air ini dinilai dalam bentuk penyingkiran kekeruhan (kaolin) dan penyingkiran warna pada UV_{254} (asid humik). Dalam kajian ini, tiga proses individu yang berbeza (pengentalan, penjerapan, dan membran penurasan ultra) dan tiga proses hibrid (pengentalan-penurasan ultra, pengentalan-penjerapan, dan pengentalan-penjerapan-penurasan ultra) telah dilaksanakan. Bagi proses penjerapan, bahan tumbuhan semulajadi iaitu kulit manggis telah dipilih dalam penyelidikan ini sebagai bahan penjerap. Proses yang digunakan dalam kajian ini adalah ujian balang dan proses pemisahan membran untuk pembekuan / penjerapan dan ultra penurasan masing-masing. Air kaolin dan air HA-kaolin digunakan sebagai air ujian dalam kajian ini. Parameter yang dikaji mengandungi kekeruhan dan UV_{254} dan ciri-ciri membran yang digunakan dan kulit manggis. Dalam proses rawatan individu, proses pengentalan didapati sangat berkesan menyingkirkan kekotoran di dalam air pada nilai pH yang tinggi sehingga mencapai kecekapan penyingkiran 97% kekeruhan dan 93% UV_{254} . Manakala, penggunaan kulit manggis dalam penjerapan kurang berkesan dalam menyingkirkan kekeruhan dan warna UV_{254}. Membran penurasan ultra didapati dapat menyingkirkan kedua-dua parameter kekeruhan dan warna UV_{254} sehingga melebihi 99%. Walau bagaimanapun, masalah pengotoran (fouling) telah menyebabkan fluks air terawat menurun cepat dalam 6 minit. Proses rawatan hibrid telah menunjukkan bahawanya adalah satu kaedah rawatan air yang lebih berkesan dan mampan berbanding rawatan individu. Untuk rawatan air melalui pengentalan-membran penurasan ultra, fluks relatif meningkat sehingga 12 dan 30 kali ganda kepada air kaolin dan air HA-kaolin apabila dibandingkan dengan proses membran penurasan ultra. Proses pengentalan-penjerapan pada pH yang tinggi menunjukkan kualiti air terawat yang lebih baik. Pada pH 8 dengan 0.1 g penjerap kulit manggis dapat mencapai penyingkiran sehingga 99% kekeruhan dan UV_{254}. Bagi proses gabungan semua kaedah, air yang dirawat selepas proses pengentalan-penjerapan yang melalui proses membran penurasan ultra menunjukkan fluks relatif yang lebih tinggi iaitu 16 dan 34 kali ganda tinggi bagi air kaolin dan air HA-kaolin. Dengan morfologi penjerap kulit manggis yang unik dan jumlah permukaan penjerapan yang besar turut mempercepatkan masa pemendapan. Secara amnya, rawatan air melalui sistem hibrid menunjukkan prestasi yang lebih baik berbanding rawatan individu dan ini dapat mengurangkan penggunaan bahan kimia terutamanya di dalam proses pengentalan, maka ini dapat mengurangkan kesan ke atas alam sekitar terhadap isu sisa di dalam loji rawatan air.

ABSTRACT

Conventional water treatment processes are not capable to meet the drinking water quality. With the aid of chemical use in the treatment process, it deteriorates the water quality by producing by-product that could affect the treated water. In line with this, this research aims to reduce the chemical use in the coagulation process. Therefore, hybrid or combination process is evaluated in this research project. Kaolin solution and humic acid were used as impurities normally found in the surface water and the process was evaluated in terms of turbidity (kaolin) and UV_{254} (humic acid) removal. In this study, three different individual processes (coagulation, adsorption, and ultrafiltration membrane) and three hybrid processes (coagulation-ultrafiltration, coagulation-adsorption, and coagulation-adsorption-ultrafiltration) are performed. For the adsorption study, natural plant-based material namely, mangosteen pericarp (MP) was used in this research as an adsorbent. The process used in the research experiment were jar test and membrane separation process for coagulation/adsorption and ultrafiltration respectively. Synthetic kaolin and humic kaolin water was used as test water in this research experiment. The parameter analyzed in this research include turbidity, UV_{254} and physical characterization on membrane and MP adsorbent. In the individual treatment process, the coagulation process could effectively remove the impurity in the water at pH 10 value up to 97% turbidity removal and 93% UV_{254} removal efficiency. Meanwhile, the solely mangosteen pericarp adsorbent used in the adsorption process did not effectively remove both turbidity and UV_{254}. The ultrafiltration was able to remove the turbidity and UV_{254} up to 99% removal, however, the fouling would caused the flux permeate rate sharply reduced within first 6 minutes. The hybrid treatment process has shown higher removal efficiency and membrane relative flux. For the coagulation/ultrafiltration, its relative flux increased up to 12 and 30 times higher for the kaolin test water and HA-kaolin test water, respectively, as compared to the solely ultrafiltration process. The coagulation/adsorption at pH 8 shows better treated water quality. At pH 8 with 0.1 g of mangosteen pericarp adsorbent can harvest up to 99% of turbidity and UV_{254}. Further subsequent ultrafiltration after coagulation/adsorption shows even higher relative flux which were 16 and 34 times higher for the kaolin test water and HA-kaolin test water respectively. The unique mangosteen pericarp adsorbent morphology and its surface adsorption volume has boosted hastening the sedimentation time consumed. In general, the hybrid system was shown a better performance than the individual process and it could reduce the chemical usage especially in coagulation, hence reduce the environmental impact on the waste issue in the treatment plant.

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LIST OF ABBREVIATIONS

BOD	Biochemical Oxygen Demand
DO	Dissolved Oxygen
NOM	Natural Organic Matters
SOCs	Synthetic Organic Chemicals
VOCs	Volatile Organic Chemicals
SEM	Scanning Electron Microscope
FTIR	Fourier Transform Infrared Spectroscopy
BET	Brunauer-Emmett-Teller
SDWA	Safe Drinking Water Act and Amendments
WHO	World Health Organization
SPAN	Suruhanjaya Perkhidmatan Air Negara
Alum	Aluminum Sulfate
DI	Deionised Water
RF	Relative Flux
NTU	Nephelometric Turbidity Units

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