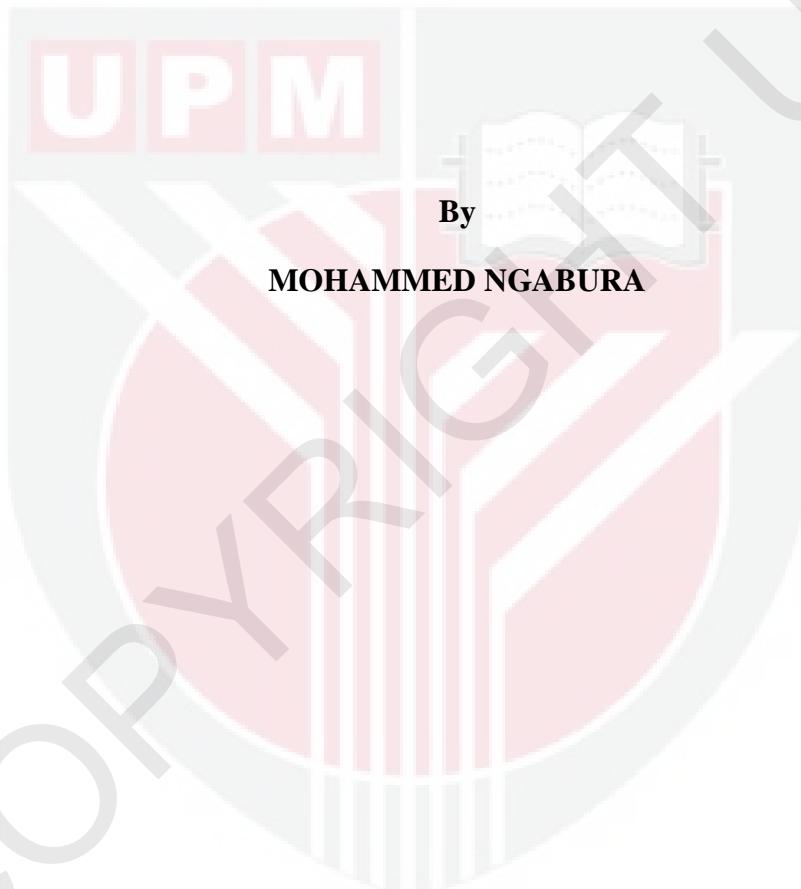**UNIVERSITI PUTRA MALAYSIA**

BATCH AND COLUMN STUDIES ON BIOSORPTION AND DESORPTION OF NICKEL ON MUSTARD OIL CAKE

MOHAMMED NGABURA

FK 2012 55

BATCH AND COLUMN STUDIES ON BIOSORPTION AND DESORPTION OF NICKEL ON MUSTARD OIL CAKE

By

MOHAMMED NGABURA

Thesis submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Master of Science

January 2012

DEDICATION

THIS THESIS IS SPECIALLY DEDICATED TO ALL MY DEAR FAMILY MEMBERS (ESPECIALLY MOMMY "AJIDDE", DADDY "NGAB", BROTHERS "MAMMAN AND MALA", SISTERS "YAKURA AND YA BAANA"), MY WIFE (ZARA KACHALLA ADAM-HABIBA TEE), LONGTIME FRIENDS (SPECIFICALLY LATE HONORABLE HAMMA SADIQ "MAY HIS GENTLE SOUL REST IN PERFECT PEACE, AMEEN", MISBAH UMAR, ABDULKARIM YUNUS, MUSTAPHA HUSSENI (SWEET MASTER), AISHA AUWAL, INNA CEE, HAUWA BATA, BILKISU ABUBAKAR (BILLY HOTGAL), AISHA HARUN, CHI CHI,), AND WELL WISHERS.

Abstract of thesis presented to the senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Master of Science.

BATCH AND COLUMN STUDIES ON BIOSORPTION AND DESORPTION OF NICKEL ON MUSTARD OIL CAKE

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January 2012

Chairman   : Associate Professor Thomas Choong Shean Yaw, PhD

Faculty   : Engineering

Discharge of industrial effluents such as electroplating of Malaysia that contains heavy metals into water bodies could results in deteriorating drinking and ground water quality. The heavy metals are non-biodegradable and show detrimental effect on flora and fauna as well as eco-system. Beyond permissible limit, toxicity of nickel was listed in this thesis. A series of batch and column laboratory studies were conducted in other to investigate the biosorption potentials of mustard oil cake (MOC). This biomass was used for minimization of Ni(II) ions from aqueous medium under different experimental conditions. This research is based on synthetic solution prepared in the laboratory. Parameters such as pH, temperature, contact time, initial nickel concentration, biosorbent dose, particle size of biosorbent and agitation speed indicated a greater influence in the biosorption process. The optimum biosorption was observed at pH 8. The biosorption increases from 0.869 to 0.915 mg/g with increase in temperature from 303 to 323 K at pH 8. Biosorbent dose studies showed increase in biosorption from 59.4 to 78.4% with increase in biosorbent dose from 0.05 to 1 g. The contact time studies revealed an equilibration time between 240 to 720 min. Adsorbate concentration studies showed an increase in biosorption capacity with increase in

reaction temperature and concentration. Spectroscopic studies indicated possible involvement of acidic (hydroxyl, carbonyl and carboxyl) groups in biosorption process. Langmuir, Freundlich and Temkin models were applied to the biosorption data. The results fitted Freundlich isotherm model which possessed high correlation coefficient (R^2) value compared to other two models. Freundlich constant (n) and activation energy (E_a) values confirmed physical nature of the process. Kinetics studies revealed applicability of Pseudo-second-order model. Thermodynamic parameters indicated that the process is endothermic and spontaneous in nature. The breakthrough and exhaustive capacities for 5 mg/L initial Ni(II) concentration were 0.25 and 4.5 mg/g, while for 10 mg/L initial Ni(II) concentration were 4.5 and 9.5 mg/g, respectively. Batch desorption studies showed 99.4 to 99.8% Ni(II) recovery with HCl solution in single-metal system. Column desorption studies were carried out at 5 and 10 mg/L initial Ni(II) concentration in single metal system. Results showed 82 and 84% of Ni(II) was recovered in initial 10 mL eluent for 5 and 10 mg/L initial Ni(II) concentrations, respectively. Regeneration studies by batch and column process confirmed reutilization of biomass without appreciable loss in biosorption. Finally, mustard oil cake was found to be cost effective and has considerable efficiency of minimizing nickel ion from aqueous solution to permissible limit.

Abatrak tesis yang dikemukakan kepada senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

KAJIAN KELOMPOK DAN TURUS KE ATAS BIOJERAPAN DAN NYAHJERAPAN NIKEL KE ATAS SAWI MINYAK KEK

Oleh

MOHAMMED NGABURA

Januari 2012

Pengerusi: Profesor Madya Thomas Choong Shean Yaw, PhD

Faculti   : Kejuruteraan

Pelepasan efluen industri seperti elektropenyaduran di Malaysia yang mengandungi logam berat ke dalam badan air boleh menyebabkan kemerosotan kualiti air minuman dan tanah. Logam berat adalah tidak biodegradasi dan menunjukkan kesan penjejasan ke atas tumbuhan dan haiwan serta eko-sistem. Melebihi had yang dibenarkan, ketoksikan nikel telah disenaraikan di dalam tesis ini. Satu siri kajian kelompok dan kajian makmal turus telah dijalankan untuk menyiasat potensi biojerapan kek minyak sawi (KMS). Biojisim ini telah digunakan untuk meminimumkan ion Ni(II) didalam bahan akueus dibawah keadaan eksperimen yang berbeza. Kajian ini adalah berdasarkan kepada penyelesaian sintetik yang disediakan di makmal. Parameter seperti pH, suhu, masa sentuhan, kepekatan nikel awal, dos biopenjerap, saiz zarah, kelajuan biopenjerap dan kelajuan getaran menunjukkan pengaruh yang besar dalam proses biojerapan. Biojerapan optimum dapat diperhatikan pada pH 8. Biojerapan meningkat dari 0.869 kepada 0.915 mg/g dengan peningkatan dalam suhu 303-323 K pada pH 8. Kajian dos biopenjerap menunjukkan peningkatan dalam biojerapan dari 59.4 kepada 78.4 % dengan peningkatan dalam dos biopenjerap dari 0.05 untuk 1 g.

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Kajian masa mendedahkan masa imbang antara 240 hingga 720 minit. Kajian kepekatan bahan terjerap menunjukkan peningkatan dalam kapasiti biojerapan dengan peningkatan suhu tindak balas dan kepekatan. Spektroskopi kajian menunjukkan kemungkinan penglibatan kumpulan berasid (hidroksil, karbonil dan karboksil) dalam proses biojerapan. Model Langmuir, Freundlich dan Temkin telah digunakan keatas data biojerapan. Keputusan menunjukkan data bersuaian dengan model isoterma Freundlich yang memiliki nilai pekali korelasi yang tinggi (R^2) berbanding dua model yang lain. Nilai malar (n) dan tenaga pengaktifan (E_a) bagi model Freundlich mengesahkan sifat fizikal semulajadi proses. Kinetik kajian menunjukkan kebolehpakaian model Pseudo-tertib kedua. Parameter termodinamik menunjukkan bahawa proses adalah endotermik dan bersifat spontan. Kapasiti yang ditemui dan yang menyeluruh untuk kepekatan awal Ni(II) sebanyak 5 mg/L masing-masing adalah 0.25 dan 4.5 mg/g, manakala bagi kepekatan awal 10 mg/L adalah 4.5 dan 9.5 mg/g. Kajian penyahjerapan berkelompok menunjukkan pemulihan 99.4 kepada 99.8 % Ni(II) dengan larutan HCl dalam sistem logam tunggal. Kajian turus penyahjerapan telah dijalankan pada kepekatan awal Ni(II) sebanyak 5 dan 10 mg/L dalam sistem logam tunggal. Hasil kajian menunjukkan 82 dan 84 % Ni(II) dapat dipulihkan dalam 10 mL eluen awal untuk 5 dan 10 mg/L kepekatan awal Ni (II) masing-masing. Kajian penjanaan semula oleh proses kelompok dan turus mengesahkan kebolehan penggunaan semula biojisim tanpa kehilangan cukup besar dalam biojerapan. Akhirnya, didapati bahawa kek minyak sawi merupakan bahan yang mempunyai kos efektif dan mempunyai kecekapan untuk meminimumkan ion nikel dari larutan akueus kepada had yang dibenarkan.

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First and foremost, thanks are to almighty Allah who empowered us to eventually witness the end of this research. I owe sincere and earnest thankfulness to my helpful supervisor Associate Professor Dr. Thomas Choong Shean Yaw and my humble co-supervisor Professor Dr. Luqman Chuah Abdullah for their guidance, insightful comments and patient supervision of this study. It is an honor for me to thank Dr. Moonis Ali Khan who profoundly assisted from the initial to the final level of this work enabled me to develop an understanding of the subject. I am sure it would have not been possible without his help. I would also like to show my gratitude to all technicians in the laboratories especially Mr. Joha and Mrs. Maslinda for their helping hands. I am also indebted to many of my colleagues such as Hassan Masood, Khumran, Kabiru Gamagiwa, Hamdan Yahaya (Abu Yemen) etc. for their constant support and encouragement.

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Finally, I would like to thank all and sundry who in one way or the other helped to make my master degree program a sounding success, but whose name I failed to mention due to my own limitations as a human being.

APPROVAL

I certify that a Thesis Examination Committee has met on 19th January 2012 to conduct the final examination of Mohammed Ngabura on his Master of Science thesis entitled "Biosorption and Desorption of Nickel on Mustard Oil Cake: Batch and Column studies" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

Members of the Thesis Examination Committee were as follows:

Azni B. Idris, PhD
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(Chairman)

Salmiaton Ali, Ph.D
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Faculty of Engineering
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Bassim Hameed, Ph.D
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Universiti Sains Malaysia
(External Examiner)

_____
SEOW HENG FONG, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 23 April 2012

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

Thomas Choong Shean Yaw, Ph.D
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Faculty of Engineering
University Putra Malaysia
(Chairman)

Luqman Chuah Abdullah, Ph.D
Professor
Faculty of Engineering
University Putra Malaysia
(Member)

BUJANG BIN KIM HUAT, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

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DECLARATION

I declared that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declared that it has not been previously or currently submitted for any other degree at Universiti Putra Malaysia or other institution.

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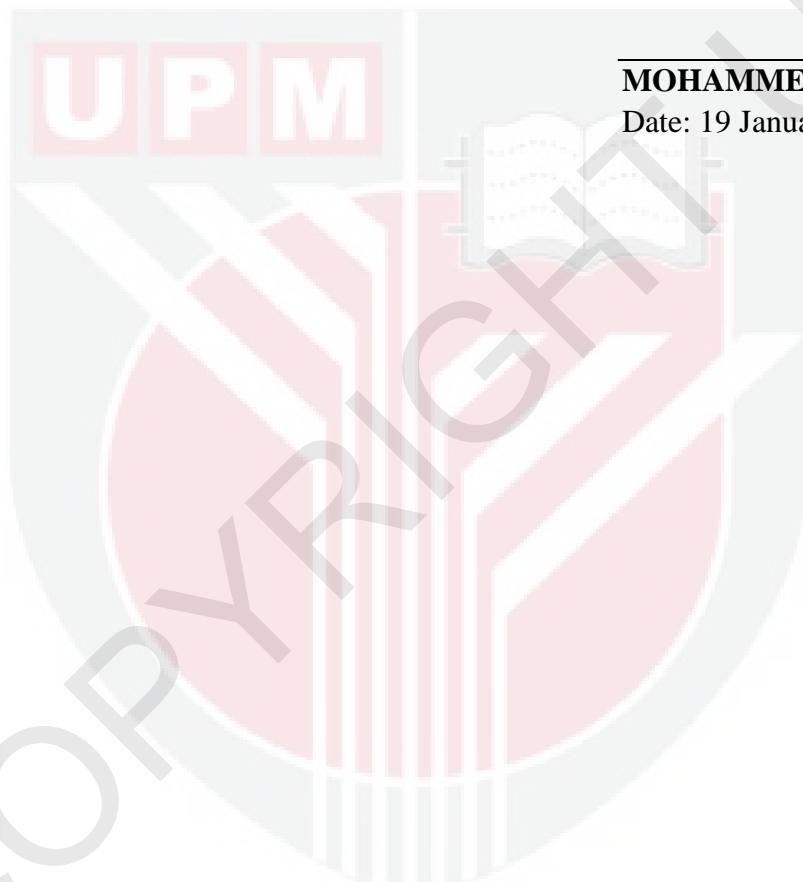
MOHAMMED NGABURA

Date: 19 January 2012

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