CAR WASH WASTEWATER TREATMENT USING KAPOK FIBER AS ADSORBENT

MUHAMMAD SHAHRUL SHAFENDY BIN IBRAHIM

A thesis submitted in
fulfillment of the requirement for the award of the
Doctor of Philosophy

Faculty of Engineering Technology
Universiti Tun Hussein Onn Malaysia

JULY 2022

DEDICATION

To my beloved **father and mother, Ibrahim and Zubaidah**

For their infinite supports and blessings

To my beloved **siblings, Aizatul Afzan and Azlin Azuin**,

For giving me infinite care, support, and blessings

To my beloved **brother-in-law, Amir Nazrin**

For his supports and care

To my beloved **niece and nephews**,

Azalea Arissa, Muhammad Aariz, and Ahmad Aariq,

For endless love

To my beloved **supervisor, Dr. Nor Haslina**

For her supports, guides and blessings.

To my beloved **friends,** especially **Saufi and Zaidi**,

For infinite encouragement and understanding

Thank you for your endless supports to me

ACKNOWLEDGEMENT

In the name of Allah, the Most Beneficent and the Most Merciful. All praise to Allah the Almighty for giving me the strengths, guidance and patience in completing this thesis. First and foremost, I would like to express my deepest gratitude to my family; Zubaidah, Ibrahim, Aizatul Afzan, Azlin Azuin, Amir, Azalea Arissa, Muhammad Amir Aariz, and Ahmad Amir Aariq for their endless love and support throughout my journey. Specifically, to my beloved niece and nephews, though you are still so young, at times I relied on you guys. I love you three so much.

My deepest appreciation goes to Assoc. Prof. Ts. Dr. Nor Haslina Hashim and Assoc. Prof. Dr. Hairul Anuar Tajuddin as my supervisors for their trust and support to improve myself. Especially, to Dr. Nor Haslina, for not only did she guide me excellently in completing this thesis, but she also highlighted me to be a better person overall. Moreover, endless gratitude goes to Ustaz Azmi for his support towards me to seek extra knowledge to become a better person from time to time. Also, I would like to thank my friends, Muhamad Senawi (*Allahyarham*), Ahmad Saufi, Mohd Saiful Zaidi, Nur Atikah, Amirza, Amnani, Yus, Fazli, Nabilah, Nazlizan, Taufik, Hadi, Rafiq, Haffiz, Aidil, Adli and others, who provided shoulders for me to lean on, hands to pull me up whenever I fell into slumps. May a bright future await us, here in this world and later in *Jannah*.

Moreover, I am also thankful to Mr. Kassim, Mr. Azwan, Mrs. Fazlyana, Mrs. Nadia and other assistant engineers in FKAAB and FTK for assistance throughout my experimental works in the laboratory at the FKAAB, UTHM. Special thanks to Dr. Arif and Ir. Dr. Abbas for sharing their knowledge with me. Lastly, I would like to express my deepest gratitude to the Ministry of Higher Education for the scholarship under MyBrain15 and Fundamental Research Grant Scheme (FRGS), Vot 1565. Also, to those that helped me directly and indirectly for the accomplishment of this project, thank you so much.

ABSTRACT

Generally, cars have been used as main mean of transportation that requires cleaning regularly and will generate the car wash wastewater (CWW). In Malaysia, the CWW is released to the public drain without any treatment and threatened the aquatic livings as it consists of mainly oil and grease (O&G) and anionic surfactant (AS) that contributes to chemical oxygen demand (COD) concentrations and did not comply with Malaysia's standard discharge limit (industrial effluent). This study proposes an efficient and easily-operated approach to treat the CWW using kapok fibre (KF). The KF has been reported to have high affinity with oils where its lumen structures and lignin layers were reported to be responsible for its efficiency. In order to confirm the importance of lumen structure and lignin, delignification on the KF was done using sodium hydroxide, hydrochloric acid and chloroform. After delignification, the structures of modified- KF (MKF) were found to be crumpled. Moreover, the raw KF (RKF) and MKFs were then used to treat the synthetic CWW to remove the COD, O&G and AS in a batch-scale study. Overall, the RKF performed the best with removal of COD, O&G and AS at 80.8, 100.0 and 24.4 % respectively at the optimum operating pH of 9, the dosage of 1.0 g and a contact time of 30 minutes. Based on the isotherm studies, the adsorption of the COD, O&G and AS onto RKF and MKF were found to lean towards physisorption and chemisorption respectively with the formation of monolayer on the surface. As RKF was more efficient in the batch-scale study, it was then used for the column study to treat real CWW and the removals of COD, O&G and AS were found to comply with the standards. The breakthrough studies of the RKF column indicates the adsorptions are dependent on the influent concentration. Moreover, the reusability of the RKF column was experimented and resulted in excellent performance up to 3 cycles. Overall, the RKF was found to be able to treat CWW efficiently up to 88 %, 100 % and 83 % removals of COD, O&G and AS respectively, thus demonstrating promising potential for real scale application.

ABSTRAK

Umumnya, kereta telah digunakan sebagai kenderaan utama yang perlu dibersihkan sekerapnya dan akan menjana air sisa cucian kereta (CWW). Di Malaysia, CWW dilepaskan ke longkang awam tanpa sebarang rawatan dan mengancam hidupan air kerana mengandungi permintaan oksigen kimia (COD), minyak dan gris (O&G) dan surfaktan viea rah (AS) yang tidak mematuhi had pelepasan piawai (efluen viea rahvi). Kajian ini mencadangkan idea yang cekap dan mudah dikendalikan bagi merawat CWW menggunakan serat kapok (KF). KF dilaporkan mempunyai tarikan tinggi terhadap minyak di mana struktur lumen dan lapisan ligninnya dilaporkan bertanggungjawab terhadap kecekapannya. Bagi mengesahkan kepentingan struktur lumen dan lignin, penyingkiran lignin pada KF dilakukan menggunakan natrium hidroksida, asid hidroklorik dan kloroform. Selepas penyingkiran lignin, kandungan lignin pada KF-diubahsuai (MKF) didapati berkurang dan strukturnya remuk. Selanjutnya, KF mentah (RKF) dan MKF digunakan untuk merawat CWW sintetik bagi penyingkirkan COD, O&G dan AS dalam kajian skala kelompok. Keseluruhannya, RKF menunjukkan prestasi terbaik dengan penyingkiran COD, O&G dan AS masing-masing pada 80.8, 100.0 dan 24.4% pada pH operasi optimum 9, dos 1.0 g dan masa sentuhan 30 minit. Penjerapan COD, O&G dan AS kepada RKF dan MKF didapati cenderung viea rah penjerapan fizikal dan penjerapan kimia masing-masing dengan pembentukan lapisan-mono pada permukaan. Oleh kerana RKF adalah lebih efisien dalam kajian skala kelompok, ia kemudiannya digunakan bagi kajian turus untuk merawat CWW sebenar dan penyingkiran COD, O&G dan AS didapati mematuhi piawai. Kajian penerobosan pada ruangan RKF menunjukkan penjerapan bergantung pada kepekatan asal. Tambahan itu, penggunaan semula turus RKF telah dieksperimentasi dan menghasilkan prestasi yang sangat baik sehingga 3 kitaran. Keseluruhannya, RKF didapati mampu merawat CWW dengan berkesan sehingga 88 %, 100 % dan 83 % penyingkiran COD, O&G dan AS masing2, lantas menunjukkan potensi yang cerah bagi aplikasi skala sebenar.

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LIST OF SYMBOLS AND ABBREVIATIONS

^{o}C	-	Degree Celsius
C_o	-	Initial Concentration
C_t	-	Final Concentration
K	-	Adsorption rate constant
N_o	-	Saturated adsorption capacity per volume
R^2	-	Coefficient of determination
R_L	-	Separation factor
T	-	Time
Q	-	Flow rate
q	-	Adsorption capacity
m	-	Mass (RKF or MKF)
mg/L	-	Milligram per liter
n	-	Heterogeneity factor
U_o	-	Liquid velocity through packed column
V	-	Volume
Z	-	Column bed depth
ANOVA	-	Analysis of variance
APHA	-	American Public Association
AS	-	Anionic surfactant
KF	-	Kapok fiber
$CHCl_3$	-	Chloroform
$CHCl_3$-*KF*	-	$CHCl_3$-treated KF
COD	-	Chemical oxygen demand
CWW	-	Car wash wastewater
FESEM	-	Field Emission Scanning Electron Microscopy

FTIR	-	Fourier Transform Infrared
HCl	-	Hydrochloric acid
HCl-KF	-	HCl-treated KF
MTZ	-	Mass transfer zone
MKF	-	Modified kapok fiber
NaOH	-	Sodium hydroxide
NaOH-KF	-	NaOH-treated KF
O&G	-	Oil and grease
RKF	-	Raw kapok fiber
$Influent_1$	-	Influent concentration in 1st batch column treatment
$Influent_2$	-	Influent concentration in 2nd batch column treatment
$Influent_3$	-	Influent concentration in 3rd batch column treatment
pH_1	-	pH values in column treatment at 1st cycle
pH_2	-	pH values in column treatment at 2nd cycle
pH_3	-	pH values in column treatment at 3rd cycle
COD_1	-	COD concentrations in RKF column treatment at 1st cycle
COD_2	-	COD concentrations in RKF column treatment at 2nd cycle
COD_3	-	COD concentrations in RKF column treatment at 3rd cycle
$O\&G_1$	-	O&G concentrations in RKF column treatment at 1st cycle
$O\&G_2$	-	O&G concentrations in RKF column treatment at 2nd cycle
$O\&G_3$	-	O&G concentrations in RKF column treatment at 3rd cycle
AS_1	-	AS concentrations in RKF column treatment at 1st cycle
AS_2	-	AS concentrations in RKF column treatment at 2nd cycle
AS_3	-	AS concentrations in RKF column treatment at 3rd cycle

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APPENDIX B

Preparations of MBAS Reagents – Standard Method 5540 C (APHA, 2012)

1. Stock standard Solution: 0.10 g sodium dodecyl sulphate (SDS) was weighed and transferred into 1 L volumetric flask and diluted to mark with ultrapure water (100 mg SDS/L).
2. Sodium hydroxide, NaOH, 1N: 40 g of NaOH was weighed and transferred into the 1 L volumetric flask and diluted to mark with ultrapure water.
3. Sulphuric acid, H_2SO_4, 1N: 28 mL of concentrated H_2SO_4 was added to ultrapure water, then transferred into 1 L volumetric flask and diluted to mark with ultrapure water.
4. Chloroform, $CHCl_3$ (*Chloroform is toxic and suspected carcinogen*)
5. Phenolphthalein, 1%: 1 g of phenolphthalein was weighed and diluted in 95% ethanol. 100 mL of ultrapure water was added.
6. Methylene blue reagent: 30 mL of 0.1% methylene blue solution was added to a 1 L volumetric flask. 500 mL ultrapure water, 6.8 mL concentrated H_2SO_4, and 50 g NaH_2PO_4. $2H_2O$ was added into the flask. Then, the mixture was diluted to mark with ultrapure water.
7. Wash solution: 6.8 mL of concentrated H_2SO_4 was added to 500 mL ultrapure water. Then, 50 g NaH_2PO_4, H_2O was added, and the mixture was transferred into 1 L volumetric flask and then diluted to mark with ultrapure water.