A NOVEL BIOADSORPTION-FLOCCULATION FLUIDIZED BED BIOREACTOR PRIOR TO MEMBRANE FILTRATION FOR WASTEWATER TREATMENT AND REUSE

By

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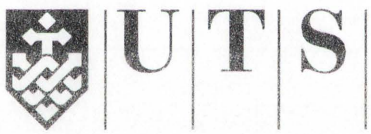

University of Technology, Sydney

Submitted in fulfillment for the degree of

Doctor of Philosophy

Faculty of Engineering and Information Technology

University of Technology, Sydney (UTS)

Australia

2012

CERTIFICATE

I certify that this thesis has not already been submitted for any degree and is not being submitted as part of candidature for any other degree.

I also certify that the thesis has been written by me and that any help that I have received in preparing this thesis, and all sources used, have been acknowledged in this thesis.

Signature of Candidate

Production Note:
Signature removed prior to publication.

I dedicate this work to my beloved parents

Anli WANG

Jianxin XING

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude and appreciation to my principal supervisor, Associate Professor Huu Hao NGO, for his valuable suggestions, ideas, support, comments and continuous guidance throughout my study. I would also like to thank my co-supervisors Dr. Wenshan GUO and Dr. Prasanthi HAGARE for their encouragement, advice and help.

The experimental work of this study was funded by ARC linkage project (LP 0775149).

I would like to thank Mr. David Hooper for helping me with my experimental equipment set-ups and repairs. Special thanks to Dr. S. H. Kim for his assisstance in mathematical modelling work. I also like to thank my fellow researchers in our research group Thanh, Ibrahim, Sherub, Bandita, Melody, Andrzej, Javeed, Zhuo, Cong, Dr. Shon, Dr.Vinh and Dr, Pham for their friendship and companionship during my study.

This thesis would never have been completed without the great support from my beloved parents. I would also like to thank my friends for their continous encouragement and support.

Thank you very much to all of you!

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NOMENCLATURE

AOB	ammonia-oxidizing bacteria
BGAC	biological GAC
BOD	biochemical oxygen demand
BTSE	biologically treated sewage effluent
C_e	fluid phase solute equilibrium concentration (mg/L)
C_i	initial organic concentration of solution (mg/L)
COD	chemical oxygen demand
DBP	disinfection by-product
DO	dissolved oxygen
DOC	dissolved organic carbon
FBBR	fluidized bed bioreactor
GAC	granular activated carbon
GAC-FBBR	granular activated carbon fluidized bed bioreactor
HRT	hydraulic retention times
iFBBR	integrated fluidized bed bioreactor
K_f	overall mass transfer coefficient (m/s)
k_f	mass transfer coefficient (1/s)
M	amount of adsorbents (g)
MF	microfiltration
MLSS	mixed liquor suspended solid
MLVSS	mixed liquor volatile suspended solid
MWCO	molecular weight cutoff
MWD	molecular weight distribution
NBF	natural based flocculant
NF	nanofiltration
NOM	natural organic matter
NSBF	new sustainable bioflocculant

OLR	organic loading rate
ORP	Oxidation-reduction potential
OUR	oxygen taking rate
ρ_p	density of particle (kg/m^3)
PAC	powdered activated carbon
PAO	phosphate-accumulating organisms
PHF	poly-a-hydroxybuterate
PTSE	primary treated sewage effluent
q	solid phase solute equilibrium concentration (mg/g)
R	radius of adsorbent (m)
RE	removal efficiency (%)
RO	reverse osmosis
ROP	refractory organic pollutant
SBCF	starch based cationic flocculant
SFB	sludge-reduction fixed-bed bioreactor
SMF	submerged microfiltration
SND	simultaneous nitrification and denitrification
SOPA	Sydney Olympic Park Authority
SOUR	specific oxygen taking rate
SS	suspended solid
t	contact time (min)
TDS	total dissolved solid
TFB	three-phase fluidized-bed
TMP	trans-membrane pressure
TOC	total organic carbon
UF	ultrafiltration
V	volume of solution (L)
VSS	volatile suspended solids
WTP	wastewater treatment plants

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ABSTRACT

As one of the advanced technologies, fluidized bed bioreactor (FBBR) with high treatment efficiency, low operating and capital costs has attracted more attention for wastewater treatment and reuse. The natural based flocculants (NBFs) are environmentally friendly and biodegradable, as well as present good flocculating ability. They can minimize environmental and health risks. Membrane technology has been developed as one of the reliable treatment methods. However, it has some limitation. Besides the high operation costs, membrane fouling is a major obstacle for the widespread application of this technology. The pretreatment technologies are an effective way for improving the filtration performance of the membrane and minimizing membrane fouling.

This study was successfully completed with a number of developments which is relevant to all the above issues. Firstly, the granular activated carbon (GAC) fluidised bed bioreactor was designed and developed through a series of study on (i) bioadsorption capacity of granular activated carbon (GAC) in terms of dissolved organic carbon (DOC) removal from wastewaters, (ii) optimization of the operating conditions of granular activated carbon fluidized bed bioreactor (GAC-FBBRs), and (iii) evaluation of GAC-FBBR for treating synthetic wastewater. Secondly, a new sustainable bioflocculant (NSBF) was developed based on the experimental study of the effect of trace nutrients on the biodegradability of a natural starch based cationic flocculant (SBCF) and the possible use of NSBF as efficient enhancer for FBBR as well as anti-membrane fouling agent for FBBR- Microfiltration (MF) hybrid system. Thirdly, a novel integrated fluidized bed bioreactor (iFBBR) was developed with the design of incorporating an aerobic sponge bioreactor (ASB-FBBR) to an anoxic granular activated carbon FBBR (GAC-FBBR). The detailed investigation on both laboratory and pilot-scale iFBBR and iFFBR-MF with NSBF addition were also conducted.

The main specific findings from this study are as follows:

Biological GAC (BGAC) bioadsorption performed significantly better than GAC adsorption. BGAC bioadsorption could lower the GAC dose and prolong the life time of GAC. The NSBF, containing 22 mg/L of SBCF, 0.5 mg/L of $FeCl_3$, 5 mg/L of $MgSO_4$ and 2 mg/L $CaCl_2$, was discovered in this study. The addition of NSBF to the GAC-FBBR, lab-scale and pilot-scale iFBBR is helpful for biomass growth and enhances the performance of bioreactors in terms of organic and nutrient removals. As a pretreatment to SMF, GAC-FBBR, lab-scale and pilot-scale iFBBR are successful in increasing the critical flux and reducing the membrane fouling. The pilot-scale iFBBR-SMF hybrid system could remove more than 95% of organics from real domestic wastewater with effluent DOC and COD concentrations of 2 mg/L and 4.5 mg/L, respectively.