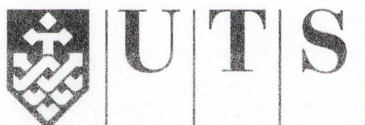


**A NOVEL
BIOADSORPTION-FLOCCULATION
FLUIDIZED BED BIOREACTOR PRIOR
TO MEMBRANE FILTRATION FOR
WASTEWATER TREATMENT AND
REUSE**

By

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Submitted in fulfillment for the degree of

Doctor of Philosophy

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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

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TABLE OF CONTENTS

TITLE PAGE	i
CERTIFICATE	ii
ACKNOWLEDGEMENT	iv
TABLE OF CONTENTS	v
NOMENCLATURE	xi
LIST OF TABLES	xiii
LIST OF FIGURES	xvi
ABSTRACT	xxi
CHAPTER 1	
INTRODUCTION	1-1
1.1 Introduction	1-2
1.2 Objectives of study	1-4
1.3 Structure of the study	1-5
CHAPTER 2	
LITERATURE REVIEW	2-1
2.1 Introduction	2-2
2.2 Wastewater reclamation and reuse	2-2
2.2.1 General	2-2
2.2.2 Global water scarcity	2-2
2.2.3 Water reuse in Australia	2-3
2.3 Characteristics of domestic wastewater	2-5
2.3.1 General	2-5
2.3.2 Organic matters in wastewater	2-8

2.4 Adsorption in wastewater treatment and reuse	2-9
2.4.1 General	2-9
2.4.2 Concept and adsorption mechanism	2-9
2.4.3 Adsorbents	2-15
2.4.4 Activated carbon adsorption and applications	2-16
2.5 Coagulation and flocculation	2-17
2.5.1 General	2-17
2.5.2 Concept	2-18
2.5.3 Flocculants and their applications	2-19
2.6 Biological nutrients removal in wastewater treatment and reuse	2-23
2.6.1 General	2-23
2.6.2. Nitrogen removal	2-25
2.6.3 Phosphorus removal	2-30
2.7 Fluidized bed bioreactor (FBBR) in wastewater treatment	2-32
2.7.1 General	2-32
2.7.2 Concept of FBBR	2-32
2.7.3. Application of FBBR and case study	2-45
2.8 Membrane technology in wastewater treatment and reuse	2-63
2.8.1 General	2-63
2.8.2 Concept of membrane technology	2-64
2.8.3 Membranes	2-65
2.8.4 Membrane fouling	2-69
2.8.5 Membrane process and applications in wastewater treatment and reuse	2-72

CHAPTER 3

EXPERIMENTAL INVESTIGATION 3-1

3.1 Introduction	3-2
3.2 Experimental materials	3-2

3.2.1 Wastewater	3-2
3.2.2 Granular activated carbon (GAC)	3-4
3.2.3 Sponge	3-4
3.2.4 Flocculant	3-5
3.2.5 Hollow fibre Membrane	3-5
3.3 Experimental Method	3-6
3.3.1 Adsorption equilibrium experiments	3-6
3.3.2 Adsorption kinetics experiments	3-7
3.3.3 Flocculation	3-8
3.3.4 Biodegradation study of SBCF	3-9
3.3.5 Laboratory-scale Granular activated carbon fluidized bed bioreactor (GAC-FBBR)	3-9
3.3.6 Laboratory-scale integrated fluidized bed bioreactor (iFBBR)	3-10
3.3.7 Laboratory-scale iFBBR- microfiltration (MF) hybrid system	3-12
3.3.8 Pilot-scale integrated fluidized bed bioreactor (iFBBR)	3-13
3.4 Experimental Analyses	3-14
3.4.1 Dissolved Organic Carbon (DOC)	3-14
3.4.2 Specific oxygen uptake rate (SOUR)	3-15
3.4.3 Zeta potential	3-16
3.4.4 Molecular Weight (MW) Distribution	3-17

CHAPTER 4

FEASIBILITY OF GRANULAR ACTIVATED CARBON FLUIDIZED BED BIOREACTOR (GAC-FBBR) IN WASTEWATER TREATMENT AND REUSE

4.1 Introduction	4-2
4.2 GAC adsorption and bioadsorption	4-4
4.2.1. Theoretical approach	4-4

4.2.2 Performance of GAC adsorption	4-6
4.2.3 Performance of GAC bioadsorption	4-11
4.3 Granular activated carbon fluidized bed bioreactor	4-17
4.3.1 Bed expansion and biomass growth	4-17
4.3.2 Performance of GAC-FBBR	4-21
4.4 Conclusions	4-30

CHAPTER 5

APPLICABILITY OF NEW SUSTAINABLE BIOFLOCCULANT	5-1
5.1 Introduction	5-2
5.2 SBCF Flocculation	5-4
5.3 Evaluation of the biodegradation of SBCF	5-5
5.3.1 Biodegradation of SBCF	5-5
5.3.2 Effect of SBCF on microbial activity	5-9
5.4 New sustainable bioflocculant (NSBF) Development	5-17
5.4.1 Combined SBCF with individual inorganic trace nutrient	5-17
5.4.2 Combination of SBCF together with FeCl ₃ , CaCl ₂ and MgSO ₄	5-20
5.5 Effect of NSBF addition to GAC-FBBR	5-23
5.5.1 Effects of NSBF addition on PTSE with and without ROPs	5-23
5.5.2 Performance comparison of GAC-FBBR and NSBF-GAC-FBBR as pretreatment to submerged microfiltration (SMF) hybrid system	5-30
5.6 Conclusions	5-32

CHAPTER 6

LABORATORY-SCALE INTEGRATED FLUIDIZED BED BIOREACTOR (iFBBR) AND iFFBR –

MICROFILTRATION (MF) HYBRID SYSTEM IN WASTEWATER TREATMENT AND REUSE	6-1
6.1 Introduction	6-2
6.2 iFBBR optimization	6-4
6.2.1 Effect of organic loading rate (OLR)	6-4
6.2.2 Effect of hydraulic retention time (HRT)	6-5
6.2.3 Effect of NSBF adding frequencies	6-6
6.3 Performance of iFBBR	6-9
6.3.1 Organic and nutrients removals	6-9
6.3.2 Mass balance	6-10
6.3.3 Biomass and microbial activities	6-12
6.3.4 Effect of NSBF on performance of iFBBR	6-13
6.4 iFBBR as pretreatment to microfiltration (MF) – iFBBR-MF hybrid system	6-14
6.4.1 Critical flux	6-14
6.4.2 Performance of lab-scale iFBBR-MF hybrid system with and without NSBF addition	6-16
6.5 Conclusions	6-18

CHAPTER 7

PILOT-SCALE INTEGRATED FLUIDIZED BED

BIOREACTOR (iFBBR) AND iFBBR-MF HYBRID

SYSTEM IN WASTEWATER TREATMENT AND REUSE	7-1
7.1 Introduction	7-2
7.2 Performance of pilot-scale iFBBR for treating real PTSE	7-2
7.2.1 Organic and nutrients removals	7-2
7.2.2 Mass balance	7-6
7.2.3 Biomass and microbial activities	7-7

7.3 Effect of NSBF on performance of iFBBR	7-8
7.4 iFBBR as pretreatment to submerged microfiltration (iFBBR-MF hybrid system)	7-10
7.4.1 Critical flux	7-10
7.4.2 Performance of iFBBR-MF hybrid system with NSBF addition (NSBF-iFBBR-MF)	7-12
7.5 Conclusions	7-13

CHAPTER 8

CONCLUSIONS AND RECOMMENDATIONS	8-1
8.1 Conclusions	8-2
8.1.1 Feasibility of granular activated carbon fluidized bed bioreactor (GAC-FBBR) in wastewater treatment and reuse	8-2
8.1.2 Applicability of new sustainable bioflocculant	8-3
8.1.3 Laboratory-scale integrated fluidized bed bioreactor (iFBBR) and iFBBR-membrane filtration (MF) hybrid system in wastewater treatment and reuse	8-4
8.1.4 Pilot-scale integrated fluidized bed bioreactor (iFBBR) and iFFBR - membrane filtration (MF) hybrid system in wastewater treatment and reuse	8-4
8.2 Recommendations	8-5

REFERENCES	R-1
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APPENDIX

Related publications	A-1
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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

LISTS OF TABLES

Table 2.1 Water use in Australia's 22 largest cities (adapted from Rathjen et al., 2003)	2-3
Table 2.2 Annual wastewater reuse from STPs in Australia, 2001 (adapted from Radcliffe, 2003)	2-4
Table 2.3 Wastewater reuse in State capital cities expressed as a percentage of sewage effluent treated, 2001 (adapted from Radcliffe, 2003)	2-5
Table 2.4 Physical, chemical and biological characteristics of wastewater and their sources (adapted from Tchobanoglous and Burton, 1991)	2-7
Table 2.5 Isotherms for adsorption system	2-13
Table 2.6 Characteristics of typical adsorbents	2-16
Table 2.7 Favourable environmental conditions for nitrification	2-28
Table 2.8 Favourable environmental conditions for denitification (adapted Wiesmann et al., 2007 and Kumar et al., 2010)	2-30
Table 2.9 Favourable environmental conditions for biological phosphorus removal (adapted from Wiesmann, 2007)	2-31
Table 2.10 Characteristics of supporting medium	2-38
Table 2.11 Disadvantages, their source and possible remedies with respect to the conventional biological treatment plants (Heijnen et al., 1989; Wright and Raper, 1996)	2-43
Table 2.12 Comparing four membrane process (adapted from WEF, 2006 and Wegnar, 2001)	2-68
Table 2.13 Typical feed water and filtrate water quality (WEF, 2006)	2-73
Table 3.1 Composition of PTSE and BTSE	3-3
Table 3.2 Characteristics of real PTSE and BTSE	3-4
Table 3.3 Characteristics of GAC used	3-4

Table 3.4 Characteristics of Flocculant	3-5
Table 3.5 Characteristics of the hollow fiber membrane module used	3-6
Table 4.1 Performance of GAC adsorption	4-8
Table 4.2 GAC adsorption Langmuir-Freundlich isotherm constants (25°C)	4-10
Table 4.3 LDFA+ Dual isotherm kinetics overall film mass transfer coefficient k_f (m/s)	4-11
Table 4.4 Performance of GAC bioadsorption	4-15
Table 4.5 GAC bioadsorption Langmuir-Freundlich isotherm constants (25°C)	4-16
Table 4.6 Critical flux with different recirculation rate	4-23
Table 4.7 Critical flux with different OLRs	4-24
Table 4.8 Critical flux with different HRTs	4-26
Table 4.9 The nutrients removal of GAC-FBBRs with and without NSBF addition (influent $\text{NH}_4\text{-N} = 16\text{-}19$ mg/L, $\text{NO}_3\text{-N} = 0.6\text{-}1.1$ mg/L, $\text{NO}_2\text{-N} = 0.01\text{-}0.02$ mg/L, T-N = 17-20 mg/L, T-P = 2.9-3.2 mg/L)	4-29
Table 5.1 Comparison of OUR variation of biomass attached on GAC with and without SBCF addition	5-11
Table 5.2 Comparison of OUR values for SBCF combined with different concentrations of CaCl_2	5-19
Table 5.3 Comparison of OUR variation for SBCF combined with different concentrations of MgSO_4	5-20
Table 5.4 The combined conditions of inorganic trace nutrients with SBCF	5-22
Table 5.5 Comparison of OUR variation with different combined flocculants	5-23
Table 5.6 The nutrients removal of GAC-FBBRs with and without NSBF addition (influent $\text{NH}_4\text{-N} = 16\text{-}19$ mg/L, $\text{NO}_3\text{-N} = 0.6\text{-}1.1$ mg/L, $\text{NO}_2\text{-N} = 0.01\text{-}0.02$ mg/L, T-N = 17-20 mg/L, T-P = 2.9-3.2 mg/L)	5-25
Table 6.1 Performance comparison of iFBBR at different HRTs in terms of organic and nutrients removals	6-6

Table 6.2 DO consumption, sponge biomass, OUR and SOUR in the iFBBR with NSBF addition	6-13
Table 7.1 Average characteristics with standard deviations of raw domestic wastewater and of effluents from iFBBR	7-3
Table 7.2 DO consumption, sponge biomass, OUR and SOUR in pilot-scale iFBBR with NSBF addition	7-8

LIST OF FIGURES

Figure 1.1 Schematic of research scope conducted in this study	1-6
Figure 2.1 Different forms of phosphorous in wastewater (adapted from Wiesmann et al., 2007)	2-24
Figure 2.2 Principal compounds in the nitrogen cycle are nitrogen gas, ammonium, organic nitrogen and nitrate (adapted from Henze et al., 2008)	2-26
Figure 2.3 Modular organization of denitrification (adapted from Zumft et al., 1997)	2-29
Figure 2.4 Mechanism of enhanced biological phosphorus removal (adapted from Wiesmann, 2007)	2-30
Figure 2.5 Configuration of FBBR ((a) anaerobic FBBR; (b) aerobic FBBR; (c) three-phase FBBR)	2-33
Figure 2.6 Effect of Biomass thickness on biodegradation (adapted from Sfferman and bishop, 1997)	2-40
Figure 2.7 Schematic of bioparticle circulating FBBR (adapted from Chowdhury et al., 2008)	2-62
Figure 2.8 Schematic diagram of the three-stage FBBR (adapted from Cheng et al., 2004)	2-62
Figure 2.9 Schematic diagram of the reactor system consisting of TFB and SFB (adapted from Feng et al., 2008)	2-63
Figure 2.10 Principle of membrane technology	2-65
Figure 2.11 Comparison of dead-end and cross flow membrane filtration	2-68
Figure 3.1 Membrane module	3-6
Figure 3.2 Platform mixer	3-7
Figure 3.3 Mechanical stirrer	3-8
Figure 3.4 Experimental set-up of laboratory-scale anaerobic GAC-FBBR	3-10
Figure 3.5 Schematic diagram of lab-scale iFBBR	3-11

Figure 3.6 Experimental set-up of iFBBR-SMF hybrid system	3-13
Figure 3.7 Schematic diagram of pilot-scale iFBBR	3-14
Figure 3.8 Multi N/C 2000 TOC analyser	3-14
Figure 3.9 Biological Oxygen Monitor	3-15
Figure 3.10 MALVERN 2000 Zetasizer	3-16
Figure 3.11 High pressure liquid chromatography (HPLC)	3-18
Figure 4.1 GAC adsorption equilibrium with Langmuir–Freundlich model (25 °C) ((a) synthetic BTSE; (b) synthetic PTSE; (c) real BTSE; (d) real sewage)	4-8
Figure 4.2 GAC adsorption kinetics with LDFA+Dual isotherm model ((a) synthetic BTSE; (b) synthetic PTSE; (c) real BTSE; (d) real sewage)	4-11
Figure 4.3 Biomass growth on GAC and SOUR of biomass	4-13
Figure 4.4 Performance of GAC bioadsorption ((a) synthetic BTSE; (b) synthetic PTSE; (c) real BTSE; (d) real sewage)	4-14
Figure 4.5 Performance comparisons of GAC adsorption and BGAC bioadsorption	4-16
Figure 4.6 Bed expansion of GAC-FBBRs for treating (a) PTSE without ROPs; (b) PTSE with ROPs	4-18
Figure 4.7 The relations between biomass growth on GAC and net bed expansion (initial GAC depth = 50 cm)	4-19
Figure 4.8 Net bed expansion of three different GACs (initial GAC depth = 50 cm)	4-20
Figure 4.9 SEM images of (a) fresh GAC; (b) GAC from FBBR	4-21
Figure 4.10 Performance of GAC-FBBR in removing DOC at different recirculation rate	4-22
Figure 4.11 Performance of GAC-FBBR in removing DOC at different OLR	4-24
Figure 4.12 Performance comparison of GAC-FBBR in terms of organic and nutrients removals	4-25

Figure 4.13 ORP variations of the GAC beds in GAC-FBBRs for treating PTSE with and without ROPs	4-27
Figure 4.14 Performance of GAC-FBBRs for treating PTSE with and without ROPs	4-28
Figure 4.15 Constant filtration fluxes vs. TMP of SMF under different feeding conditions (a) PTSE with ROPs; (b) effluent from GAC-FBBR	4-30
Figure 5.1 SBCF flocculation for DOC removal from BTSE and zeta potential	5-4
Figure 5.2 Biodegradability of SBCF in terms of BOD ₅ /COD variation and degradation of DOC	5-6
Figure 5.3 Biomass growth of mixed liquor with time	5-7
Figure 5.4 SOUR variation of mixed liquor versus time	5-7
Figure 5.5 Relative viscosity versus time to study the biodegradation of SBCF with and without nutrients addition (temperature =25 °C)	5-8
Figure 5.6 MLSS and MLVSS growth	5-10
Figure 5.7 Comparison of SOUR variation	5-10
Figure 5.8 Biomass growth on GAC in three GAC-FBBRs with and without SBCF addition	5-12
Figure 5.9 DOC removal efficiencies of three GAC-FBBRs with and without SBCF addition (average initial DOC=120mg/L)	5-13
Figure 5.10 Performances of GAC-FBBR with and without SBCF addition (depth=500mm, average initial DOC=10mg/L)	5-14
Figure 5.11 Effect of FBBR as pretreatment on critical flux (flux unit: L/m ² .h; (a) BTSE without pretreatment, (b) GAC-FBBR pretreated BTSE, (c) SBCF-GAC-FBBR pretreated BTSE)	5-15
Figure 5.12 MW distribution of the BTSE with different FBBRs pretreatment	5-17
Figure 5.13 Biomass attached on GAC for 22 mg/L of SBCF	

combined with different concentrations of CaCl ₂	5-18
Figure 5.14 Biomass attached on GAC for 22 mg/L of SBCF	
combined with different concentrations of MgSO ₄	5-20
Figure 5.15 Biomass attached on GAC with different combinations	
of flocculants on 15th day	5-22
Figure 5.16 DOC removal efficiency of the different combined flocculants	
(initial DOC=120 mg/L)	5-23
Figure 5.17 Performance of GAC-FBBRs and NSBF-GAC-FBBRs	
for treating PTSE with and without ROPs	5-24
Figure 5.18 ORP variations of the GAC beds in GAC-FBBRs and	
NSBF-GAC-FBBRs for treating PTSE with and without ROPs	5- 26
Figure 5.19 Bed expansion of GAC-FBBRs and NSBF-GAC-FBBRs	
for treating (a) PTSE without ROPs; (b) PTSE with ROPs	5-27
Figure 5.20 Net bed expansion of three different GACs	5-29
Figure 5.21 SEM images of (a) GAC from GAC-FBBR;	
and (b) GAC from NSBF-GAC-FBBR	5-30
Figure 5.22 Constant filtration fluxes vs. TMP of SMFunder	
different feeding conditions (a) PTSE with ROPs;	
(b) effluent from GAC-FBBR; and	
(c) effluent from NSBF-GAC-FBBR	5-31
Figure 6.1 Performance comparison of iFBBR with different OLRs	6-5
Figure 6.2 Comparison of iFBBR with different HRTs	
in terms of microbial activity	6-6
Figure6.3 Biomass and microbial activity with the different	
frequency of NSBF addition	6-8
Figure 6.4 Organic and nutrients removal of the iFBBR with NSBF addition	6-9
Figure 6.5 Organic and nutrients removals in specific iFBBR	
with NSBF addition	6-10
Figure 6.6 Mass balances in the iFBBR	6-12

Figure 6.7 Performance comparison of the iFBBR with and without NSBF addition	6-14
Figure 6.8 Constant filtration fluxes vs. TMP of SMF under different feeding conditions (a) PTSE; (b) effluent from iFBBR; and (c) effluent from iFBBR with NSBF addition	6-15
Figure 6.9 TMP development of MF	6-17
Figure 6.10 Organic and nutrients removals in NSBF-iFBBR-MF hybrid system	6-17
Figure 7.1 Organic removal from real PTSE in pilot-scale iFBBR with NSBF addition	7-3
Figure 7.2 Nutrients removal from real PTSE in pilot-scale iFBBR with NSBF addition	7-5
Figure 7.3 Mass balances in pilot-scale iFBBR	7-6
Figure 7.4 Performance comparison of the iFBBR with and without NSBF addition	7-9
Figure 7.5 Constant filtration fluxes vs TMP of SMF under different feeding conditions (a) PTSE; (b) effluent from iFBBR without NSBF; (c) effluent from iFBBR with NSBF	7-10
Figure 7.6 TMP development of MF	7-12
Figure 7.7 Organics and nutrients removals in NSBF-iFBBR-SMF hybrid system	7-13

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 FeCl₃, 5 mg/L of MgSO₄ and 2 mg/L CaCl₂, 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.