CARBON, NITROGEN AND PHOSPHORUS REMOVAL FROM DOMESTIC WASTEWATER BY ALTERNATING AEROBIC-ANOXIC PROCESS

NOORUL HUDAI BT ABDULLAH

A thesis submitted in fulfilment of the
requirements for the award of the degree of
Doctor of Philosophy (Civil Engineering)

Faculty of Civil Engineering
Universiti Teknologi Malaysia

JANUARY 2017

This thesis is dedicated to:

Special dedication to my late father, Abdullah Bin Abdul Rahman who taught me how to read and how to write. The person dreamed to see me one day high educated. He left the life but his dream still alive.

Special dedication to my beloved mother, mother-in-law and father-in-law, Che Meriam Binti Che Soh, Zainun Binti Awang and Abd Rahman Bin Mohamed, without them none of my success would be possible.

To my beloved husband Mohd Hilmi Bin Abd Rahman, he has been a source of motivation and strength during moment of discouragement and despair.

Thanks for advices, affections continued supports and supplications during my study

and lastly,

Special thanks to my beloved sisters, brothers and all my friends, who always together through thick and thin, guidance and encouragement to finish my study. May Allah SWT bless all of you with all prosperity, happiness, wisdom and good health in this world and the Hereafter.

Ammen Ya Rabbal Alamin.

ACKNOWLEDGEMENT

The most important acknowledge is to our Lord Most Merciful Most Wise by whose mercy I was able to successful completion of this PhD study. His Mercy is such that unworthy slave like me is given the ability to work in His cause through which I remember Him SWT and be grateful towards all He has given me. Allah states in the Quran **'Then remember Me; I will remember you. Be grateful to Me, and do not ungrateful to Me'** (al-Baqarah 2: 152), May Allah accept my humble work as an effort to remember and thank Him SWT. Ameen Ya Rabbal Alameen.

I would like to express my deep and sincere gratitude to my supervisor, Assoc. Prof. Dr. Mohamad Ali Fulazzaky and my co-supervisor Prof. Dr. Abdull Rahim Bin Mohd Yusoff for their patience, understanding, encouragement and personal guidance that I have been able to complete this study. I am grateful for all of the opportunities that they have provided me. This research would not have seen the light of day were it not for the help of many people and several organisations.

I wish to express my warm and sincere thanks to all staff in Centre for Environmental Sustainability & Water Security (IPASA) for allowing me to use their laboratory facilities. I would like also to express my appreciations to my colleagues in IPASA laboratory whose have taught me so much and help me to get through my work in the laboratory including Atikah, Hairul, Shakila, Maria, Amerreza, Mimi, Aziah, Hazwan and all students and staff in Environmental Laboratory Faculty of Civil Engineering, University Teknologi Malaysia. I wish to extend my warmest thanks to my collaborated, Indah Water Konsortium to allowing and helping me to collect the sample during this research and also the sponsorship from Ministry of Higher Education Malaysia (MyPhD) and the grant from University Teknologi Malaysia.

ABSTRACT

Excessive amount of nutrients (nitrogen and phosphorus) released from wastewater may lead to degradation of the receiving water and can induce adverse effects on human health and the environment. The use of coupled nitrification-denitrification can significantly remove major pollutants from domestic wastewater, however researchers only have limited understanding of the alternating aerobic-anoxic process in a single reactor and therefore needs to be verified. This study performed treatment using an alternating aerobic-anoxic (AAA) process in a single reactor to remove major pollutants from domestic wastewater i.e., carbon, nitrogen and phosphorus. Comparative analysis of the coupled nitrification-denitrification reactions was carried out to investigate different periods of nitrification-denitrification cycles and to analyse the effect of initial dissolved Fe/P molar ratio and pH on iron-hydroxide-phosphate precipitation. The results indicated that 3-h aerobic digestion and 3-h anoxic time was the best cycle to remove the pollutants where the removal efficiencies of COD and NH_4^+ were verified as high as 97% and 87%, respectively, achieving the desired inorganic nitrogen concentration of less than 10 $mgNL^{-1}$ in the outflow to meet stringent effluent standards. The denitrification/ nitrification ratio of 2.1, indicates that denitrification occurs in the reactor faster than nitrification because it can prevail over nitrifying bacteria in competition for reaction kinetics. The AAA treatment process to remove soluble reactive and total phosphorus from domestic wastewater had a moderate efficiency. Two types of $Fe_4(OH)_9PO_4$ and $Fe_5(OH)_6(PO_4)_3$ precipitate may occur in different conditions of the AAA process. The results advance the understanding that proper AAA treatment effectively removes carbon, nitrogen and phosphorus pollution from domestic wastewater. The contribution of this study in removal of major pollutants from domestic wastewater will require future assessment in a prospective wastewater treatment facilities setting.

ABSTRAK

Nutrien berlebihan (nitrogen dan fosforus) yang dilepaskan dari air sisa boleh menurunkan kualiti dan boleh menyebabkan kesan buruk kepada kesihatan manusia dan alam sekitar. Penggunaan nitrifikasi-denitrifikasi boleh menyinsihkan bahan pencemar utama dari air sisa domestik, pemahaman penyelidik terhad dalam proses selang seli aerobik-anoksik dalam reaktor tunggal dan perlu disahkan. Kajian ini telah menjalankan proses selang seli aerobik-anoksik (AAA) dengan reaktor tunggal untuk menghapuskan bahan pencemar utama dari air sisa domestik seperti contoh karbon, nitrogen dan fosforus. Analisis perbandingan reaksi nitrifikasi-denitrifikasi telah dijalankan untuk menyiasat perbezaan tempoh kitaran nitrifikasi-denitrifikasi dan menganalisis kesan awal nisbah molar Fe/P dan pH dalam mendakan ferum-hidroksil-fosfat. Keputusan menunjukkan kitaran 3-jam aerobik dan 3-jam anoksik adalah kitaran yang terbaik dalam menghapuskan bahan pencemar, di mana kecekapan penyingkiran bagi COD dan NH_4^+ adalah 97% dan 87%, mencapai kepekatan nitrogen inorganik yang dikehendaki kurang dari 10 $mgNL^{-1}$ dalam aliran keluar untuk memenuhi piawaian efluen yang ketat. Dengan nisbah denitrifikasi/ nitrifikasi ialah 2.1, ini menunjukkan bahawa denitrifikasi berlaku dalam reaktor cepat berbanding nitrifikasi kerana ia boleh mengatasi bakteria nitrifikasi dalam persaingan untuk tindak balas kinetik. Proses rawatan AAA untuk membuang fosforus reaktif larut dan fosforus daripada air sisa domestik mempunyai kecekapan yang sederhana. Dua jenis mendakan $Fe_4(OH)_9PO_4$ dan $Fe_5(OH)_6(PO_4)_3$ boleh berlaku dalam keadaan proses AAA. Keputusan kajian rawatan AAA efektif untuk menyingkirkan karbon, nitrogen dan fosforus daripada air sisa domestik. Sumbangan kajian ini telah menyingkiran karbon, nitrogen, fosforus daripada air sisa domestik dan memerlukan penilaian pada masa hadapan dalam rawatan fasiliti air sisa.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGEMENT	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	vii
	LIST OF TABLES	xi
	LIST OF FIGURES	xii
	LIST OF ABBREVIATIONS	xvi
	LIST OF SYMBOLS	xviii
	LIST OF APPENDICES	xix
1	**INTRODUCTION**	**1**
	1.1 Introduction	1
	1.2 Problems statement	2
	1.3 Objectives of the study	3
	1.4 Scope of the study	4
	1.5 Research significances	5
	1.6 Organisation of the thesis	6
2	**LITERATURE REVIEW**	**7**

2.1 Introduction 7

2.2 Domestic wastewater 9

2.2.1 Characteristics of domestic wastewater 10

2.2.2 Major pollutants in domestic wastewater 12

2.2.3 Regulations 14

2.3 Alternating Aerobic-Anoxic Treatment process 16

2.3.1 Alternating Aerobic-Anoxic process for carbon and nitrogen removal 16

2.3.2 Alternating Aerobic-Anoxic process for phosphorus removal 20

2.4 Summary 22

3 MATERIALS AND METHODS 24

3.1 Introduction 24

3.2 Stages of experimental run 25

3.3 Domestic wastewater 27

3.3.1 Characterisation of the domestic wastewater 28

3.4 Discontinuous aerobic-anoxic reactor 28

3.4.1 Stage of the experimental run 30

3.4.1.1 Aerobic digestion process 31

3.4.1.2 Alternating aerobic-anoxic treatment processes 32

3.4.1.3 Precipitation of iron-hydroxy-phosphate of added ferric iron 33

3.5 Analytical methods 34

3.6 Summary 37

4 APPLICATION OF ALTERNATING AEROBIC-ANOXIC PROCESS FOR THE REMOVAL OF CARBON AND FOR THE SELECTION OF THE BEST CONDITION OF ANOXIC TIME-AEROBIC DIGESTION CYCLE 38

4.1 Introduction 38

4.2 Characteristics of domestic wastewater 39

4.3 Aerobic digestion process 40
4.4 Conditioning the Alternating Aerobic-Anoxic treatment process 47
4.4.1 Ratio of denitrification to nitrification 52
4.5 Summary 53

5 APPLICATION OF ALTERNATING AEROBIC-ANOXIC PROCESS FOR THE REMOVAL OF INORGANIC NITROGEN POLLUTION 54
5.1 Introduction 54
5.2 Conditioning the experimental environments 55
5.3 Experimental data validation 59
5.3.1 The three different experimental environments 59
5.3.2 The two different alternating aerobic-anoxic periods 61
5.4 Summary 66

6 APPLICATION OF ALTERNATING AEROBIC-ANOXIC PROCESS FOR THE REMOVAL OF PHOSPHATE OF WITH ADDITIONAL OF FERRIC IRON 67
6.1 Introduction 67
6.2 Experimental data validation 68
6.2.1 Biological phosphorus removal conditions 68
6.2.2 Precipitation of iron-hydroxy-phosphate during water flows into the reactor 69
6.2.3 Precipitation of iron-hydroxy-phosphate in the reactor 72
6.2.3.1 Iron-hydroxy-phosphate accumulation in activated sludge 72
6.2.3.2 Influences of Fe/P molar ratio and pH 74
6.2.4 Phosphorus removal efficiency 76
6.3 Summary 79

7 CONCLUSIONS AND RECOMMENDATIONS 80

7.1 Conclusions 80

7.2 Recommendations 81

REFERENCES 83

Appendices A - D 98-116

LIST OF TABLES

TABLE NO.	TITLE	PAGE
2.1	Principal of concern in wastewater treatment (Tchobanoglous *et al.*, 2004; Henze & Comeau, 2008)	11
2.2	Minimum national standards for secondary treatment (Tchobanoglous *et al.*, 2004)	14
2.3	The Urban Wastewater Treatment Directive (91/271/EEC) sets discharge limits for wastewater treatment plants. Values for total phosphorus and nitrogen only apply to discharges > 10, 000 population equivalents (PE) discharging to surface waters classed as sensitive (e.g. those subject to eutrophication) (Gray, 2004).	15
2.4	Acceptable conditions of sewage discharge of standard A and B (DOE, 2009)	16
3.1	Operating parameters of the AAA treatment process	30
3.2	The categories of alternating aerobic-anoxic treatment process (AD=Aerobic digestion process, AT=Anoxic time process)	33
3.3	The parameters and methods used for the experiments	33
4.1	Main characteristics of domestic wastewater from IWK treatment plant at Taman Impian Emas, Skudai, Johor.	39
4.2	Expected condition according to the SVI values (Spellman, 2013)	41
4.3	Three different condition of the AAA processes	48
5.1	Urban wastewater treatment directive 91/271/EEC	58

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
2.1	Application of the Alternating Aerobic-Anoxic treatment process	8
3.1	Stage of experimental run	25
3.2	Operational frame work	26
3.3	Indah Water Konsortium treatment plant at Taman Impian Emas, Skudai, Johor Bahru, Malaysia	27
3.4	Schematic of Discontinous Aerobic Anoxic Reactor	29
4.1	Evolution of MLSS concentration in accordance with *t* under the Aerobic Digestion conditions	41
4.2	Variation of the SVI value in accordance with *t* under the Aerobic Digestion conditions	42
4.3	Linear regression analysis of plotting the organic loading rate versus the rate of organic removal.	42
4.4	Variation of SS concentration in accordance with *t* under the Aerobic Digestion conditions	43
4.5	Variation of COD removal efficiency in accordance with *t* under the Aerobic Digestion conditions	44
4.6	Variation of NH_4^+ removal efficiency in accordance with *t* under the Aerobic Digestion conditions	44
4.7	Variation of TP removal efficiency in accordance with *t* under the Aerobic Digestion conditions	45

4.8	Results of monitoring the inorganic nitrogen concentrations (i.e., blue for influent NH_4^+ concentration, red for effluent NH_4^+ concentration, and green for effluent NO_3^- concentration) and the inorganic nitrogen pollutant removal efficiency (purple) for three different experimental conditions.	46
4.9	Cycles of nitrification-denitrification for the same Anoxic Time and Aerobic Digestion periods of: (a) 6-6 h, (b) 5-5 h, (c) 4-4 h, (d) 3-3 h, (e) 2-2 h, (f) 1-1 h and (g) 0.5-0.5 h (INP: inorganic nitrogen pollutant, NH_4^+ plus NO_3^-)	50
4.10	Cycles of nitrification-denitrification for the different Aerobic Digestion and Anoxic Time periods of: (a) 4-2 h, (b) 2-1 h, (c) 1-0.5 h, (d) 2-4 h, (e) 1-2 h and (f) 0.5-1 h (INP: inorganic nitrogen pollutant, NH_4^+ plus NO_3^-)	51
4.11	Performance of the Alternating Aerobic-Anoxic treatment process to remove COD and inorganic nitrogen concentrations	52
4.12	Ratio of denitrification to nitrification in accordance with cycle of Anoxic Time and Aerobic Digestion period	53
5.1	Results of monitoring the inorganic nitrogen concentrations (i.e., black for influent NH_4^+ concentration, red for effluent NH_4^+ concentration, and blue for the effluent NO_3^- concentration) and the INP removal efficiency (green) for three different experimental conditions. Note that AD means aerobic digestion, AAA means alternating aerobic-anoxic process and AM means addition of methanol.	56
5.2	Linear regression analysis for the correlation between the organic loading rate and organic removal rate. The straight line has a slope of 0.8583 and intercepts at minus 0.0083 with R^2= 0.9614.	57

5.3	Results of monitoring the inorganic nitrogen concentrations at outlet of the reactor during the Alternating Aerobic-Anoxic processes (i.e., black for NH_4^+ concentration, red for NO_3^- concentration, and green for NH_4^+ plus NO_3^- concentrations) to run a single test for alternating aerobic (3 h) and anoxic (6 h) process. Note that AD means aerobic digestion and AT means anoxic time.	62
5.4	Results of monitoring the inorganic nitrogen concentrations at outlet of the reactor during the Alternating Aerobic-Anoxic processes (i.e., black for NH_4^+ concentration, red for NO_3^- concentration, and green for NH_4^+ plus NO_3^- concentrations) to run a single test for alternating aerobic (3 h) and anoxic (3 h) process. Note that AD means aerobic digestion and AT means anoxic time.	63
5.5	Variations of pH (black) and redox potential (red) pursuant to time for the alternating aerobic (3 h) and anoxic (6 h) process. Note that AD means aerobic digestion and AT means anoxic time.	66
6.1	Variations of DO, pH, redox potential and temperature	69
6.2	Variations of added ferric iron concentration and concentration of SRP removal	70
6.3	Variations of influent TP concentration, amount of TP accumulation and TP/ MLSS ratio	72
6.4	Variations of Fe/P molar ratio and phosphorus removal efficiency	75
6.5	Variations of concentrations and phosphorus removal efficiency of SRP	77
6.6	Variations of concentrations and phosphorus removal efficiency of TP	78

LIST OF ABBREVIATIONS

AAA	-	Alternating aerobic-anoxic
AD	-	Aerobic digestion
AM	-	Addition of methanol
AT	-	Anoxic time
BOD	-	Biochemical oxygen demand
C	-	Carbonaceous
COD	-	Chemical oxygen demand
DAAR	-	Discontinuous aerobic-anoxic reactor
D/N	-	Denitrification/Nitrification
DO	-	Dissolved oxygen
DOE	-	Department of Environment
F/M	-	Food to microorganism
HRT	-	Hydraulic retention time
IHP	-	Iron-hydroxy-phosphate
INC	-	Inorganic nitrogen concentration
INP	-	Inorganic nitrogen pollution
IWK	-	Indah Water Konsortium
MLSS	-	Mixed liquor suspended solids

N	-	Nitrogenous
N_2	-	Nitrogen gas
NH_4^+	-	Ammonium
NO_2^-	-	Nitrite
NO_3^-	-	Nitrate
NTK	-	Nitrogen Total Kjeldahl
ORP	-	Oxidation reduction potential
P	-	Phosphorous
SRP	-	Soluble reactive phosphorus
SRT	-	Sludge retention time
SS	-	Suspended solids
SVI	-	Sludge volume index
WWTP	-	Wastewater treatment plant

LIST OF SYMBOLS

t	-	Time (day)
R^2	-	Correlation coefficient (dimensionless)

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	List of Publications	98
B	Aerobic Digestion Process	99
C	Alternating Aerobic-Anoxic Treatment Process	106
D	The Physical and Chemical Characteristics and Typical Composition of Untreated Domestic Wastewater	115

CHAPTER 1

INTRODUCTION

1.1 Introduction

Water as medium for waste transport would be easily contaminated by human activities. Many methods have been proposed to treat contaminated water to protect human health and the environment. In order to upgrade the existing wastewater treatment facilities, the typical advanced technologies have been proposed to remove many types of pollutant, effectively (Tchobanoglous *et al.*, 2004). The development of wastewater treatment plant need to be considered leading economic indicators to having low operational and maintenance costs (Shammas *et al.*, 2009; Lewandowski, 2015). Aerobic digestion (AD) has been known since 1950 as biological wastewater treatment process to remove organic compounds, colloids and suspended solids to avoid the excessive pollutants released into the receiving water (Shammas and Wang, 2007). Currently, the most popular wastewater treatment techniques include extended aeration, sequencing batch reactor and oxidation ditch. The use of activated sludge in biological treatment processes under aerobic, anoxic and anaerobic conditions can remove carbon, nitrogen and phosphorus due to the presence of microorganisms and air (Tsuneda *et al.*, 2006; Fulazzaky, 2009; Romero *et al.*, 2013).

Nitrification has two successive processes of converting NH_4^+ to NO_2^- by *Nitrosomonas* bacteria and then NO_2^- to NO_3^- by *Nitrobacter* bacteria. Denitrification is the biological reduction of $NO_3^-$to nitrogen gas (N_2) by facultative heterotrophic bacteria (Risgaard-Petersen et al., 2006). During denitrification, some chemoorganotrophs are capable of replacing O_2 with NO_3^- as the terminal electron acceptor under certain conditions. The overall process of reduction of NO_3^- to N_2 is carried out by a variety of bacteria such as *Alcaligenes, Achromobacter, Micrococcus* and *Pseudomonas* (Caldwell et al., 1979;Mara and Horan, 2003).

The removal of nutrients (nitogen and phosphorus) has become the priority in treating domestic wastewater because of the excessive amount of these elements might affect human health and the receiving water body (Sedlak, 1991). The important things for improving the quality of water and living environment are to remove the major pollutants of carbon, nitrogen and phosphorus containing in domestic wastewater (Fulazzaky, 2009). This study used a laboratory scale alternating aerobic-anoxic reactor to remove carbon, nitrogen and phosphorus from domestic wastewater.

1.2 Problems statement

Effluent of domestic wastewater treatment plants contains high concentrations of nutrients that may lead to the degradation of the receiving water quality. The excessive of nutrients in aquatic ecosystems can induce adverse effects on human health and the environment (Camargo and Alonso, 2006). The immediate removal of contaminated wastewater from their sources, followed by treatment, reuse, or dispersal into the environment, is necessary to protect public health and the environment. There are several types of wastewater treatment plants to remove the pollutants from domestic wastewater for instance trickling filter, extended aeration,

sequencing batch reactor and oxidation ditch; however, these types of wastewater treatment plants are using more than one reactor to remove the pollutants. The design of secondary domestic wastewater treatment plants is usually based on the need to reduce carbon, nitrogen and phosphorus to limit pollution of the environment. Most domestic wastewater treated in wastewater treatment plants includes a variety of physical, chemical and biological treatment processes. Even though a better removal efficiency of suspended matter (SS), biochemical oxygen demand (BOD) or chemical oxygen demand (COD) can be achieved by many types of conventional biological wastewater treatment plants, simultaneous removal of nitrogen and phosphorus from a domestic wastewater need to be verified to meet a stringent effluent standard regulated by the law. In order to remove the three major pollutants (i.e., carbon, nitrogen and phosphorus), this study proposed the alternating aerobic-anoxic (AAA) using a single-sludge reactor to remove the pollutants from domestic wastewater. An understanding of AAA treatment process for removal efficiency is crucial to investigate, because of limited understanding of AAA treatment process in a single-sludge reactor.

1.3 Objectives of the study

The objectives of this study are as follows:

1) to have a configuration of pilot plant with a design that can be applied by using activated sludge to reduce carbon based on typical characteristics of domestic wastewater and to ensure the possibility of using the AAA conditions for the removal of nitrogen and phosphorus.

2) to assess the efficiencies of the AAA treatment process for nitrogen removal by comparing two different AAA time periods that drive the coupled nitrification-denitrification in single activated sludge.

3) to define the empirical formula for complex solids of iron-hydroxy-phosphate (IHP) precipitates caused by simultaneous precipitations of $FePO_4$ and $Fe(OH)_3$ in different experimental conditions and to assess the overall performance of the AAA process for the removal of phosphorus from domestic wastewater.

1.4 Scope of the study

The scopes of this study are:

1) to monitor BOD, COD, SS, NH_4^+, NO_2^-, NO_3^-, PO_4^{3-}, pH, DO, salinity and temperature to having an insight on the characteristic of raw domestic wastewater collected from Indah Water Konsotium (IWK) wastewater treatment plant at Taman Impian Emas, Skudai, Johor Bahru, Malaysia.

2) to perform the treatment of wastewater under the AD conditions until it reaches a stable rate of COD removal.

3) to conduct the experiments under the AAA treatment conditions with the different operations of same anoxic time (AT) – aerobic digestion (AD) period and different AT - AD period for the selection of the best AT - AD cycle.

4) to condition the best AT - AD cycle of AAA treatment system for assessing the possibility of using this new biotechnological treatment process in the future.

5) to verify the application of AAA treatment process for precipitation of IHP of added $FeCl_3$.

1.5 Research significances

The significances of this study are summarised bellow:

1) The use of AAA treatment process in a single reactor to remove carbon, nitrogen and phosphorus can be operated with low operating costs because it can reduce capital investment, energy consumption and human labour.

2) The conditioning of the AAA treatment system can have an insight on the application of this new biotechnological process in the future.

3) The precipitation of IHP can enhance the usability of AAA treatment process in removing three major pollution elements (carbon, nitrogen and phosphorus) of domestic wastewater.

1.6 Organisation of the thesis

Chapter 1 discusses background, problem statements, objectives, scope, and significant of the study. Chapter 2 reviews the related issues of carbon, nitrogen and phosphorus removed from domestic wastewater under aerobic, anoxic, anaerobic and alternating aerobic-anoxic conditions. Chapter 3 elaborates the materials and methods for the use of AAA treatment system to remove carbon, nitrogen and phosphorus from domestic wastewater. Chapter 4 discusses the applications of aerobic digester to remove organic matters and AAA treatment process for the selection of the best AT - AD cycle. Chapter 5 discusses the conditioning of the AAA treament system to remove inorganic nitrogen pollution (INP) from domestic wastewater. Chapter 6 attempts to precipitate the IHP for enhancing the usability of the AAA treatment process. Chapter 7 concludes the recommendation of the research study.

REFERENCES

Akin, B.S. & Ugurlu, A. (2004) The effect of an anoxic zone on biological phosphorus removal by a sequential batch reactor. *Bioresource Technology*, 94, 1–7.

American Public Health Association, APHA. 2009. *Standard Methods for the Examination of Water and Wastewater,* D.C: APHA (21th Edition).

Ammary, B.Y. (2004) Nutrients requirements in biological industrial wastewater treatment. *African Journal of Biotechnology*, 3, 236–238.

Anderson, I. & Levine, J. (1986) Relative rates of nitric oxide and nitrous oxide production by nitrifiers, denitrifiers, and nitrate respirers. *Applied and Environmental Microbiology*, 51, 938-945.

Arvin, E. & Petersen, G. (1980) A general equilibrium model for the precipitation of phosphate with iron and aluminium. *Program Water Technology*, 12, 283–298.

Arvin E., and Skaarup, J. (1979) An equilibrium model for the removal of soluble phosphate with ferrous iron in simultaneous precipitation plants, *Vatten*, 35 125–137.

Aiyuk, S., Amoako, J., Raskin, L., Van Haandel, A. & Verstraete, W. (2004) Removal of carbon and nutrients from domestic wastewater using a low investment, integrated treatment concept. *Water Research*, 38, 3031–3042.

Bae, H.S., Cho, Y.G., Oh, S.E., Kim, I.S., Lee, J.M. & Lee, S.T. (2002) Anaerobic degradation of pyrrolidine and piperidine coupled with nitrate reduction. *Chemosphere*, 48, 329–334.

Bellucci, M., Ofit¸eru, I.D., Graham, D.W., Head, I.M., & Curtis, T.P., (2011) Low-dissolved- oxygen nitrifying systems exploit ammonia-oxidizing bacteria with unusually high yields. *Applied Environment Microbiology,* 77, 7787-7796.

Borden, R.C., Gomez, C.A. & Becker, M.T. (1995) Geochemical Indicators of Intrinsic Bioremediation. *Ground Water*, 33, 180-189.

Burrell, L.S., Johnston, C.T., Schulze, D., Klein, J., White, J.L. & Hem, S.L. (2000) Aluminium phosphate adjuvants prepared by precipitation at constant pH. Part II: physicochemical properties. *Vaccine*, 19, 282–287.

Caldwell, B.A., Hagedorn, C. & Denison, W.C. (1979) Bacterial Ecology of an Old-Growth Douglas-Fir Canopy. *Microbiology Ecology*, 5, 91–103.

Camargo, J.A. & Alonso, Á. (2006) Ecological and toxicological effects of inorganic nitrogen pollution in aquatic ecosystems: A global assessment. *Environment International*, 32, 831–849.

Campos, J.L., Garrido, J.M., Mosquera-Corral, A., & Mendez, R., (2007) Stability of a nitrifying activated sludge reactor. *Biochemical Engineering J*ournal, 35, 87-92.

Castignetti, D. (1990) Bioenergetic examination of the heterotrophic nitrifier-denitrifier Thiosphaera pantotropha. *Antonie van Leeuwenhoek*, 58, 283–9.

Cébron, A., Berthe, T. & Garnier, J. (2003) Nitrification and Nitrifying Bacteria in the Lower Seine River and Estuary (France) Nitrification and Nitrifying Bacteria in the Lower Seine River and Estuary (France). *Society*, 69, 7091–7100.

Cha, Y., Stow, C.A., Nalepa, T.F. & Reckhow, K.H. (2011) Do invasive mussels restrict offshore phosphorus transport in lake huron? *Environmental Science and Technology*, 45, 7226–7231.

Chandran, K., & Smets, B.F. (2005) Optimizing experimental design to estimate ammonia and nitrite oxidation biokinetic parameters from batch respirograms. *Water Research*, 39, 4969-4978.

Chen, X., Peltier, E., Sturm, B.S.M. & Young, C.B. (2013) Nitrogen removal and nitrifying and denitrifying bacteria quantification in a stormwater bioretention

system. *Water Research*, 47, 1691–1700.

Cheng, X., Huang, X., Wang, X., Zhao, B., Chen, A. & Sun, D. (2009) Phosphate adsorption from sewage sludge filtrate using zinc-aluminum layered double hydroxides. *Journal of Hazardous Materials*, 169, 958–964.

Cheremisinoff, N.P. (1996a) *Biological treatment of industrial wastes: mutant bacteria. in: Biotechnology for Waste and Wastewater Treatment.* United State: Noyes.

Cheremisinoff, N.P. (1996b). *Nitrification and Denitrifiction in the activated sludge process in: Biotechnology for Waste and Wastewater Treatment.* United State: Noyes.

Choi, J.H., Maruthamuthu, S., Lee, H.G., Ha, T.H., Bae, J.H. & Alshawabkeh, A.N. (2010) Removal of phosphate from agricultural soil by electrokinetic remediation with iron electrode. *Journal of Applied Electrochemistry*, 40, 1101–1111.

Choubert, J.-M., Marquot, A., Stricker, A.E., Racault, Y., Gillot, S., & Heduit, A. (2009) Anoxic and aerobic values for the yield coefficient of the heterotrophic biomass: Determination at full-scale plants and consequences on simulations. *Water SA,* 35, 103-110.

Chuang, S.H. & Ouyang, C.F. (2000) The biomass fractions of heterotrophs and phosphate-accumulating organisms in a nitrogen and phosphorus removal system. *Water Research*, 34, 2283–2290.

Chuang, S.H., Ouyang, C.F., (2000) The biomass fractions of heterotrophs and phosphate-accumulating organisms in a nitrogen and phosphorus removal system. *Water Research*, 34, 2283-2290.

David, W.M. & Johnstone. (2003) *Effluent discharge standards. in: The Handbook of Water and Wastewater Microbilogy.* United Kingdom: Academic Press.

De Gregorio, C., Caravelli, A.H. & Zaritzky, N.E. (2010) Performance and biological indicators of a laboratory-scale activated sludge reactor with phosphate simultaneous precipitation as affected by ferric chloride addition. *Chemical*

Engineering Journal, 165, 607–616.

De Haas, D.W., Wentzel, M.C. & Ekama, G.A. (2000) The use of simultaneous chemical precipitation in modified activated sludge systems exhibiting biological excess phosphate removal Part 1: Literature review. *Water SA*., 27, 117–134.

Department of Environment (2009*). Environmental Quality Act (Sewage) Regulation.* Putrajaya.

Donnert, D. & Salecker, M. (1999) Elimination of phosphorus from municipal and industrial waste water. *Water Science and Technology*, 40, 195–202.

Fernandez, C., Farías, L., (2012) Assimilation and regeneration of inorganic nitrogen in a coastal upwelling system: ammonium and nitrate utilization. *Marine Ecology Progress Series,* 451, 1-14.

Fulazzaky, M.A. (2009) Carbonaceous, Nitrogenous and Phosphorous matters removal from domestic wastewater by an activated sludge reactor of nitrification and denitrification type. *Journal of Engineering Science and Technology*, 4, 69–80.

Fulazzaky, M.A. (2013a) Calculation of the release of total organic matter and total mineral using the hydrodynamic equations applied to palm oil mill effluent treatment by cascaded anaerobic ponds. *Bioprocess and Biosystems Engineering*, 36, 11–21.

Fulazzaky, M.A., Talaiekhozani, A. & Hadibarata, T. (2013b) Calculation of optimal gas retention time using a logarithmic equation applied to a bio-trickling filter reactor for formaldehyde removal from synthetic contaminated air. *Royal Society Chemistry Advances*, 3, 5100–5107.

Fulazzaky, M.A., Khamidun, M.H. & Omar, R. (2013c) Understanding of mass transfer resistance for the adsorption of solute onto porous material from the modified mass transfer factor models. *Chemical Engineering Journal*, 228, 1023–1029.

Fulazzaky, M.A., Talaiekhozani, A., Majid, M.Z.A., Ponraj, M. & Goli, A. (2013d) Evaluation of gas retention time effects on the bio-trickling filter reactor performance for treating air contaminated with formaldehyde. *Royal Society Chemistry Advances*, 3, 17462–17468.

Fytianos, K., Voudrias, E. & Raikos, N. (1998) Modelling of phosphorus removal from aqueous and wastewater samples using ferric iron. *Environmental Pollution*, 101, 123–130.

Gao, D., Peng, Y., Wu, W.M., (2010) Kinetic model for biological nitrogen removal using shortcut nitrification-denitrification process in sequencing batch reactor. *Environment Science Technology,* 44, 5015-5021.

Garcia, R.O., Reichenbach, H., Ring, M.W. & Müller, R. (2009) Phaselicystis flava gen. nov., sp. nov., an arachidonic acid-containing soil *myxobacterium*, and the description of *Phaselicystidaceae fam. nov*. *International Journal of Systematic and Evolutionary Microbiology*, 59, 1524–1530.

Ge, S., Peng, Y., Qiu, S., Zhu, A. & Ren, N. (2014) Complete nitrogen removal from municipal wastewater via partial nitrification by appropriately alternating anoxic/aerobic conditions in a continuous plug-flow step feed process. *Water Research*, 55, 95–105.

Gerardi, M.H. (2002) *Nitrification and Denitrification in the Activated Sludge Process*. New York: John Wiley and Sons.

Ginige, M.P., Bowyer, J.C., Foley, L., Keller, J. & Yuan, Z. (2009) A comparative study of methanol as a supplementary carbon source for enhancing denitrification in primary and secondary anoxic zones. *Biodegradation*, 20, 221–234.

Gray, N.F. (2004) *Wastewater treatment biology of second edition in: Series on Environmental Science and Management*. pp. 1421, London: Imperial College Press.

Grguric, G., (2002) Denitrification as a model chemical process. *Journal Chemical Education*, 79, 179-182.

Guglielmi, G. & Andreottola, G. (2011) Alternate anoxic/aerobic operation for nitrogen removal in a membrane bioreactor for municipal wastewater treatment. *Water Science & Technology*, 64, 1730-1735.

Gunnars, A., Blomqvist, S., Johansson, P. & Andersson, C. (2002) Formation of Fe(III) oxyhydroxide colloids in freshwater and brackish seawater, with incorporation of phosphate and calcium. *Geochimica et Cosmochimica Acta*, 66, 745–758.

Habermeyer, P., Sanchez, A., (2005) Optimization of the intermittent aeration in a full-scale wastewater treatment plant biological reactor for nitrogen removal. *Water Environment Research*, 77, 229-233.

Hall, E.K., Singer, G.A., Pölzl, M., Hämmerle, I., Schwarz, C., Daims, H., Maixner, F. & Battin, T.J. (2011) Looking inside the box: using Raman microspectroscopy to deconstruct microbial biomass stoichiometry one cell at a time. *The Multidisciplinary Journal of Microbial Ecology journal*, 5, 196–208.

Hamlin, H.J., Michaels, J.T., Beaulaton, C.M., Graham, W.F., Dutt, W., Steinbach, P., Losordo, T.M., Schrader, K.K. & Main, K.L. (2008) Comparing denitrification rates and carbon sources in commercial scale upflow denitrification biological filters in aquaculture. *Aquacultural Engineering*, 38, 79–92.

Hamoda, M.F. & Bin-Fahad, R.A. (2012) Nitrogen removal from wastewater in an anoxic–aerobic biofilm reactor. *Journal of Water Reuse and Desalination*, 2, 165-174.

Hanhan, O., Insel, G., Yagci, N.O., Artan, N., & Orhon, D., (2011) Mechanism and design of intermittent aeration activated sludge process for nitrogen removal. *Journal Environment Science Health,* 46, 9-16.

Hao, O.J., & Huang, J., (1996) Alternating aerobic-anoxic process for nitrogen removal: process evaluation. *Water Environment Reserach,* 68, 83-93.

Hasar, H. & Ipek, U. (2010) Gas Permeable-Membrane for Hydrogenotrophic Denitrification. *CLEAN - Soil, Air, Water*, 38, 23–26.

Heinen, M., (2006) Simplified denitrification models: overview and properties. *Geoderma,* 133, 444-463.

Henze, M. & Comeau, Y. (2008) *Wastewater Characterization. Biological Wastewater Treatment: Principles Modelling and Design*. London: IWA Publishing.

Hsu, P.H. (1975) Precipitation of phosphate from solution using aluminum salt. *Water Research*, 9, 1155–1161.

Huang, B., Feng, H., Wang, M., Li, N., Cong, Y. & Shen, D. (2013) The effect of C/N ratio on nitrogen removal in a bioelectrochemical system. *Bioresource Technology*, 132, 91–98.

Ju, L.-K., Huang, L. & Trivedi, H. (2007) Simultaneous Nitrification, Denitrification, and Phosphorus Removal in Single-Tank Low-Dissolved-Oxygen Systems Under Cyclic Aeration. *Water Environment Research*, 79, 912–920.

Kantartzi, S., Melidis, P., Aivasidis, A., (2010) Intermittent feeding of wastewater in combination with alternating aeration for complete denitrification and control of filaments. *Water Science Technol*ogy, 61, 2259-2266.

Kavanaugh, M.C., Krejci, V. & Weber, T. (1978) Phosphorus removal by post-precipitation with Fe(III). *Journal of the Water Pollution Control Federation*, 50, 216–233.

Keller, G. (1996) Utilization of inorganic and organic nitrogen sources by high-subalpine *ectomycorrhizal* fungi of *Pinus cembra* in pure culture. *Mycological Research*, 8, 989–998.

Kool, D.M., Dolfing, J., Wrage, N. & Van Groenigen, J.W. (2011) Nitrifier denitrification as a distinct and significant source of nitrous oxide from soil. *Soil Biology and Biochemistry*, 43, 174–178.

Lage, M.D., Reed, H.E., Weihe, C., Crain, C.M. & Martiny, J.B.H. (2010) Nitrogen and phosphorus enrichment alter the composition of ammonia-oxidizing bacteria in salt marsh sediments. *The Multidisciplinary Journal of Microbial Ecology*, 4, 933–944.

Lam, P. & Kuypers, M.M. (2011) Microbial nitrogen cycling processes in oxygen minimum zones. *Annual Review Marine Science,* 3, 317-345

Lee, C. & Fletcher, T.D. (2009) Nitrogen removal in constructed wetland systems. *Engineering Life Science,* 9, 11–22.

Lewandowski, C.M. (2015) *The effects of brief mindfulness intervention on acute pain experience: An examination of individual difference in Wastewater Microbiology.* John Wiley & Sons: New Jersey.

Li, C., Ji, M., Li, X., Song, Y., Zhang, Y. & Li, W. (2010) Full-scale anoxic-aerobic SBR system for simultaneous nitrogen and phosphorus removal from municipal wastewater. pp.1-4 in: 4th International Conference on Bioinformatics and Biomedical Engineering.

Li, C., Ma, J., Shen, J. & Wang, P. (2009) Removal of phosphate from secondary effluent with Fe_2^+ enhanced by H_2O_2 at nature pH/neutral pH. *Journal of Hazardous Materials*, 166, 891–896.

Lin, Y., Tay, J., Liu, Y. & Hung, Y. (2009) *Biological Nitrification and Denitrification Processes in: Handbook of Environmental Engineering*. New Jersey: The Humana Press.

Lipponen, M.T.T., Suutari, M.H., Martikainen, P.J., (2002) Occurrence of nitrifying bacteria and nitrification in Finnish drinking water distribution systems. *Water Research*, 36, 4319-4329.

Lipschultz, F., Zafiriou, O.C., Wofsy, S.C., Mcelroy, M.B., Valois, F.W. & Watson, S.W. (1981) Production of NO and N_2O by soil nitrifying bacteria. *Nature*, 294, 641–643.

Liu, G. & Wang, J. (2012) Probing the stoichiometry of the nitrification process using the respirometric approach. *Water Research*, 46, 5954–5962.

Liu, Y., Shi, H., Li, W., Hou, Y. & He, M. (2011). Inhibition of chemical dose in biological phosphorus and nitrogen removal in simultaneous chemical precipitation for phosphorus removal. *Bioresource Technology*, 102, 4008–4012.

Luedecke, C., Hermanowicz, S.W. & Jenkins, D. (1989) Precipitation of ferric phosphate in activated sludge: A chemical model and its verification. *Water Science and Technology*, 21, 325–337.

Luedecke, C., Hermanowicz, S.W. & Jenkins, D. (1989) Precipitation of ferric phosphate in activated sludge: A chemical model and its verification. *Water Science and Technology*, 21, 325–337.

Maldonado, J., de los Rios, A., Esteve, I., Ascaso, C., Puyen, Z.M., Brambilla, C. & Sole, A. (2010) Sequestration and in vivo effect of lead on DE2009 microalga, using high-resolution microscopic techniques. *Journal of Hazardous Materials*, 183, 44–50.

Manas, P., Castro, E. & De Las Heras, J. (2014) Application of treated wastewater and digested sewage sludge to obtain biomass from *Cynara cardunculus L. Journal of Cleaner Production*, 67, 72–78.

Mara, D. (2004) *Domestic Wastewater Treatment in Developing Countries*. London: Earthscan.

Mara, D., Horan, N. & Hao, O.J. (2003) *Handbook of Water and Wastewater Microbiology. in: Handbook of Water and Wastewater Microbiology*. United Kingdom: Academic Press.

Messer, J.J., Brezonik, P.L., (1984) Laboratory evaluation of kinetic parameters for lake sediment denitrification models. *Ecology Model,* 21, 277-286.

Mittal, A. (2011) Biological wastewater treatment. *Water Today*, 32–44.

Mohamed, N.M., Saito, K., Tal, Y. & Hill, R.T. (2010) Diversity of aerobic and anaerobic ammonia-oxidizing bacteria in marine sponges. *The Multidisciplinary Journal of Microbial Ecology*, 4, 38–48.

Morgan, B. & Lahav, O. (2007) The effect of pH on the kinetics of spontaneous Fe(II) oxidation by O_2 in aqueous solution - basic principles and a simple heuristic description. *Chemosphere*, 68, 2080–2084.

Morgan, W.E. & Fruh, E.G. (1974) Phosphate incorporation in activated sludge.

Journal of the Water Pollution Control Federation, 46, 2486-2497.

Nair, A.T. & Ahammed, M.M. (2015) The reuse of water treatment sludge as a coagulant for post-treatment of UASB reactor treating urban wastewater. *Journal of Cleaner Production*, 96, 272–281.

Ni, B.J., Ruscalleda, M.I., Pellicer-Nacher, C., Smets, B.F., (2011) Modeling nitrous oxide production during biological nitrogen removal via nitrification and denitrification: extensions to the general ASM models. *Environment Science Technology*, 45, 7768-7776.

Norton, J.M., Stark, J.M., (2011) Regulation and measurement of nitrification in terrestrial systems. *Methods Enzymology,* 486, 343-368.

Nowak, O., Enderle, P., Varbanov, P., (2015) Ways to optimize the energy balance of municipal wastewater systems: lessons learned from Austrian applications. *Journal Cleaner Production,* 88, 125-131.

Nyenje, P.M., Foppen, J.W., Kulabako, R., Muwanga, A. & Uhlenbrook, S. (2013) Nutrient pollution in shallow aquifers underlying pit latrines and domestic solid waste dumps in urban slums. *Journal of Environmental Management*, 122, 15–24.

Oleszkiewicz, J.A. & Barnard, J.L. (2006) Nutrient removal technology in North America and the European Union: A review. *Water Quality Research Journal of Canada*, 41, 449-462.

Omoike, A.I. & Vanloon, G.W. (1999) Removal of phosphorus and organic matter removal by alum during wastewater treatment. *Water Research*, 33, 3617–3627.

Passarini, K.C., Pereira, M.A., Farias, T.M.D.B., Calarge, F.A. & Santana, C.C. (2014) Assessment of the viability and sustainability of an integrated waste management system for the city of Campinas (Brazil), by means of ecological cost accounting. *Journal of Cleaner Production*, 65, 479–488.

Pathak, B. (2011) *Household-centered environmental sanitation systems in: Water and Sanitation-Related Diseases and the Environment: Challenges, Interventions,*

and Preventive Measures, First Edition. Canada: John Wiley & Sons.

Peng, Y., Hou, H., Wang, S., Cui, Y. & Zhiguo, Y. (2008) Nitrogen and phosphorus removal in pilot-scale anaerobic-anoxic oxidation ditch system. *Journal of Environmental Sciences*, 20, 398–403.

Peng, Y., Hou, H., Wang, S., Cui, Y. & Zhiguo, Y. (2008) Nitrogen and phosphorus removal in pilot-scale anaerobic-anoxic oxidation ditch system. *Journal of Environmental Sciences*, 20, 398–403.

Pintathong, P., Richardson, D.J., Spiro, S. & Choorit, W. (2009) Influence of metal ions and organic carbons on denitrification activity of the halotolerant bacterium, Paracoccus pantotrophus P16 a strain from shrimp pond. *Electronic Journal of Biotechnology*, 12, 1–11.

Pons, M.N., Bonté, S. Le & Potier, O. (2004) Spectral analysis and finger printing for biomedia characterisation. *Journal of Biotechnology*, 113, 211–230.

Ravitch, D. (2011) National Standards in American Education: A Citizen's Guide. Washington D.C: Brookings Institution Press.

Risgaard, N.P., Langezaal, A.M., Ingvardsen, S., Schmid, M.C., Jetten, M.S.M., Op den Camp, H.J.M., Derksen, J.W.M., Piña-Ochoa, E., Eriksson, S.P., Nielsen, L.P., Revsbech, N.P., Cedhagen, T. & van der Zwaan, G.J. (2006) Evidence for complete denitrification in a benthic foraminifer. *Nature*, 443, 93–96.

Robertson, L. a & Kuenen, J.G. (1990) Thiosphaera pantotropha and other bacteria. *Antonie van Leeuwenhoek*, 57, 139–152.

Romero, C., Ramos, P., Costa, C., & Marquez, M.C., (2013) Raw and digested municipal waste compost leachate as potential fertilizer: comparison with a commercial fertilizer. *Journal Cleaner Production*, 59, 73-78.

Rostkowski, K.H., Pfluger, A.R. & Criddle, C.S. (2013) Stoichiometry and kinetics of the PHB-producing Type II methanotrophs Methylosinus trichosporium OB3b and Methylocystis parvus OBBP. *Bioresource Technology*, 132, 71–77.

Schon, G., Geywrrz, S. & Mertens, F. (1993) Oxidation-Reduction Potential on

Phosphate Phosphorus Removal. *Water Research,* 27, 349–354.

Sedlak, R. (1991) *Phosphorus and Nitrogen Removal from Municipal Wastewater Principles and Practice.* New York: The Soap and Detergent Association.

Shah, S.I.A., Kostiuk, L.W. & Kresta, S.M. (2012) The effects of mixing, reaction rates, and stoichiometry on yield for mixing-sensitive reactionspart II: Design Protocols. *International Journal of Chemical Engineering*, Article ID 654321,1-3.

Shammas, N.K. & Wang, L.K. (2007) *Aerobic Digestion. in: Handbook of Environmental Engineering.* New Jersey: Humana Press.

Shammas, N.K., Wang, L.K. & Wu, Z. (2009) Handbook of Environmental Engineering, Volume 8: Waste Stabilization Ponds and Lagoons. *Biological Treatment Processes*, 8, 315–370.

Sinsabaugh, R.L. & Follstad Shah, J.J. (2012) Ecoenzymatic Stoichiometry and Ecological Theory. *Annual Review of Ecology, Evolution, and Systematics*, 43, 313–343.

Sorokin, D.Y., Tourova, T.P., Antipov, A.N., Muyzer, G., & Kuenen, J.G., (2004) Anaerobic growth of the haloalkaliphilic denitrifying sulfur-oxidizing bacterium *Thialka- livibrio thiocyanodenitrificans sp. nov*. with *thiocyanate*. *Microbiology,* 150, 2435-2442

Spellman, F.R. (2013) *Handbook of Water and Wastewater Treatment Plant Operations, Third Edition.* United States: CRC Press.

Sperling, M. Von & Chernicharo, C.A.D.L. (2005) *Biological Wastewater Treatment in Warm Climate Regions.* India: IWA publishing.

Sperling, M. Von. (2008) Basic principles of wastewater treatment. London: IWA Publishing.

Sperling, M. Von. (2008) *Wastewater characteristics, treatment and disposal*. London: IWA Publishing.

Spott, O., Russow, R. & Stange, C.F. (2011) Formation of hybrid N_2O and hybrid N_2

due to codenitrification: First review of a barely considered process of microbially mediated N-nitrosation. *Soil Biology and Biochemistry*, 43, 1995–2011.

Stumm, W.W. & Morgan, J.J. (1996) *Aquatic Chemistry: Chemical Equilibria and Rates in Natural Waters.* New York: Wiley.

Tandukar, M., Machdar, I., Uemura, S., Ohashi, A. & Harada, H. (2006) Potential of a Combination of UASB and DHS Reactor as a Novel Sewage Treatment System for Developing Countries : Long-Term Evaluation. *Journal of Environmental Engineering*, 132, 166–172.

Tchobanoglous, G., Burton, F.L. & Stensel, H.D. (2004) *Wastewater Engineering: Treatment and Reuse*. New York: McGraw-Hill Education.

Tezuka, Y. (1990) Bacterial regeneration of ammonium and phosphate as affected by the carbon:nitrogen:phosphorus ratio of organic substrates. *Microbial ecology*, 19, 227–38.

Van, J.R., Tal, Y. & Schreier, H.J. (2006) Denitrification in recirculating systems: Theory and applications. *Aquacultural Engineering*, 34, 364–376.

Vieno, N. & Sillanpaa, M. (2014) Fate of diclofenac in municipal wastewater treatment plant - A review. *Environment International*, 69, 28–39.

Voegelin, A., Senn, A.C., Kaegi, R., Hug, S.J. & Mangold, S. (2013) Dynamic Fe-precipitate formation induced by Fe(II) oxidation in aerated phosphate-containing water. *Geochimica et Cosmochimica Acta*, 117, 216–231.

Von, U.G. (2003) Ozonation of drinking water: Part I. Oxidation kinetics and product formation. *Water Research*, 37, 1443–1467.

Wang, C.C. & Lee, C.M. (2001) Denitrification with acrylonitrile as a substrate using pure bacteria cultures isolated from acrylonitrile-butadiene-styrene wastewater. *Environment International*, 26, 237–241.

Wang, J., Peng, Y. & Chen, Y. (2011) Advanced nitrogen and phosphorus removal in A2O-BAF system treating low carbon-to-nitrogen ratio domestic wastewater.

Frontiers of Environmental Science & Engineering in China, 5, 474–480.

Wang, Y., Shen, Z., Niu, J. & Liu, R. (2009) Adsorption of phosphorus on sediments from the Three-Gorges Reservoir (China) and the relation with sediment compositions. *Journal of Hazardous Materials*, 162, 92–98.

Wang, Y., Shen, Z., Niu, J. & Liu, R. (2009) Adsorption of phosphorus on sediments from the Three-Gorges Reservoir (China) and the relation with sediment compositions. *Journal of Hazardous Materials*, 162, 92–98.

Wentzel, M.C., Ekama, G.A. & Loewenthal, R.E. (2003) Fundamentals of biological behaviour and wastewater strength tests in: Handbook of Water and Wastewater Microbiology. United Kingdom: Academic Press.

Xu, X., Liu, G. & Zhu, L. (2011) Enhanced denitrifying phosphorous removal in a novel anaerobic/aerobic/anoxic (AOA) process with the diversion of internal carbon source. *Bioresource Technology*, 102, 10340–10345.

Yeoman, S., Stephenson, T., Lester, J.N. & Perry, R. (1988) The removal of phosphorus during wastewater treatment: A review. *Environmental Pollution*, 49, 183–233.

Zeng, W., Peng, Y. & Wang, S. (2007) Process evaluation of an alternating aerobic-anoxic process applied in a sequencing batch reactor for nitrogen removal. *Frontiers of Environmental Science & Engineering in China*, 1, 28–32.

Zhang, B. & Gao, T. (2000) An anoxic / anaerobic / aerobic process for the removal of nitrogen and phosphorus from wastewater. *Journal of Environmental Science and Health , Part A : Toxic / Hazardous Substances and Environmental Engineering*, 35, 37–41.

Zhang, J.Z. & Huang, X.L. (2011) Effect of temperature and salinity on phosphate sorption on marine sediments. *Environmental Science and Technology*, 45, 6831–6837.

Zhang, P. & Qi, Z. (2007) Simultaneous nitrification and denitrification in activated sludge system under low oxygen concentration. *Frontiers of Environmental Science & Engineering in China*, 1, 49–52.

Zhang, X., Wang, Z. & Zhao, Q. (2006) Biological phosphorus removal with nitrite as election acceptor. *Water Science and Technology*, 53, 185–191.

Zhao, Y., Zhang, Y., Ge, Z., Hu, C., Zhang, H., (2014) Effects of influent C/N ratios on wastewater nutrient removal and simultaneous greenhouse gas emission from the combinations of vertical subsurface flow constructed wetlands and earth- worm eco-filters for treating synthetic wastewater. *Environment Science Process Impacts,* 16, 567-575.

Zhou, X., Li, Y. & Zhao, Y. (2014) Removal characteristics of organics and nitrogen in a novel four-stage biofilm integrated system for enhanced treatment of coking wastewater under different HRTs. *Royal Science Chemistry Advances*, 4, 15-20.

Zhou, Y., Xing, X.H., Liu, Z., Cui, L., Yu, A., Feng, Q. & Yang, H. (2008) Enhanced coagulation of ferric chloride aided by tannic acid for phosphorus removal from wastewater. *Chemosphere*, 72, 290–298.

Zhu, R., Zhu, J., Ge, F. & Yuan, P. (2009) Regeneration of spent organoclays after the sorption of organic pollutants: A review. *Journal of environmental management*, 90, 3212–3216.