TEXTILE WASTEWATER TREATMENT USING MAGNETIC POWDER ACTIVATED CARBON BIOGRANULES

AHMAD HANIS BIN OMAR @ OMRI

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

School of Civil Engineering
Faculty of Engineering
Universiti Teknologi Malaysia

JANUARY 2020

ACKNOWLEDGEMENT

In the name of Allah the Most Gracious, the Most Merciful. First and foremost I am truly grateful for the blessings of Allah that gives me the strength to complete this thesis. I would like to convey my highest gratitude to all my supervisors; Associate Professor Dr. Khalida Muda and Associate Professor Dr. Zaiton Abdul Majid for their excellent supervision, encouragement, understanding and patience throughout my study. May Allah bless and reward all of them.

A special thanks to my research assistant Kak Mawar and Fadziana for helping me in experimental works. To Dr. Susilawati, thank you very much for assisting me on the statistical analysis. I would also like to express my thanks to Dr. Henry Ezechi for helping me in completing my thesis. I would also like to express my appreciation to all the laboratory staff; Encik Razale, Puan Rahimah, Puan Syuhada and Encik Jemahari. I would also like to extend my thanks to all my seniors, my colleagues and dear friends especially to Amir Syafiq, Basri, Aidil, Amerul, Ezzul, Hazman, Ranjeni and Julie Asni for the continuous support, advice and motivation during my study.

I am sincerely indebted to my parents and other family members for all the love, support and du’a. Lastly to my precious wife, Nur Insyirah, thank you very much for all the unconditional love, support, sacrifice and du’a during the hard times. I am deeply thankful to my wife and family-in-law for taking care of my beloved son Adam Harith during my study. All of you are my reasons to continue striving and overcome all obstacles.

Special thanks to the Ministry of Science Technology and Innovation (MOSTI) and UTM for funding this research under a project number 03H91.

ABSTRACT

Biogranulation technology is novel in the field of biological wastewater treatment with high removal potential as well as providing economical and technical advantages. This technology has been widely tested in the degradation of various types of wastewater owing to its unique sludge properties and high biodegradability potential. Despite its unique characteristics, the major drawback of biogranulation is the long start-up period. This study investigated the possibility of developing biogranules with magnetic powder activated carbon (MPAC) in treating synthetic textile wastewater. This study was aimed at enhancing biogranules development process with better characteristics and high removal performance. At early stage of this study, the effects of magnetic field and MPAC on the initial process development of biogranules were studied using one factor at a time (OFAT) and response surface methodology (RSM). The cultivation of biogranules was then investigated using two laboratory scale sequencing batch reactors (SBR) under intermittent anaerobic and aerobic conditions. Reactor R1 acted as a control system while reactor R2 was added with MPAC. The reactors were designed with 3 L of total working volume and operated at 50% volumetric exchange rate. These biogranules were cultivated with a mixture of textile mill and municipal wastewater sludge. The systems were fed with synthetic textile wastewater. Removal performances, structural aspects and formation of MPAC biogranules were examined based on physical, biological and chemical properties. Batch test results showed that static magnetic field induction and MPAC gave significant positive effect on improving the initial biogranulation process. After 60 days of development stage in the SBR system, the average size of the biogranules increased, reaching 2.0 mm ± 0.5 with an average settling velocity of 44 m/h and sludge volume index (SVI) of 34 mL/g. Total biomass concentration was 8.2 g/L, which was observed to be beneficial for the performance of the system. The extracellular polymeric substances (EPS) of newly developed biogranules were also measured in this study. The total EPS content for these biogranules was 0.083 g. SBR system containing MPAC biogranules showed the best removal performance when operated with 24 hours hydraulic retention time (HRT) with an intermittent of anaerobic (18 hours) and aerobic (6 hours) reactions. The highest removal performance for color, ammonia, TOC and COD were 83%, 98%, 95% and 97%, respectively. The final stage of the study involved the development of an artificial neural network (ANN) for the prediction of the biogranules performance at different HRT and reaction phases. The ANN model has successfully predicted the color removal performance with regression (R^2) of 0.9923 and mean square errors (MSE) of $2.75e^{-05}$. This study demonstrated that the addition of MPAC in the development of biogranules has demonstrated significant improvement in the physical, biological and chemical characteristics of the newly developed biogranules. The addition of MPAC could shorten and improve the biogranulation development where MPAC acts as the support media for microbial attachment during the development of biogranules.

ABSTRAK

Teknologi biogranulasi adalah suatu yang baru dalam bidang rawatan air sisa biologi dengan potensi penyingkiran yang tinggi serta mempunyai kelebihan dari segi ekonomi dan teknikal. Teknologi ini telah diuji secara meluas dalam merawat pelbagai jenis air sisa oleh kerana sifat enapcemar yang unik dan potensi biodegradasi yang tinggi. Walaupun cirinya unik, kekurangan utama biogranulasi adalah tempoh pembentukannya mengambil masa yang panjang. Kajian ini menyiasat kemungkinan untuk menghasilkan biogranul dengan serbuk karbon aktif magneti (MPAC) dalam merawat air sisa tekstil sintetik. Kajian ini bertujuan untuk meningkatkan proses pembentukan biogranul dengan ciri yang lebih baik dan prestasi penyingkiran yang tinggi. Pada peringkat awal kajian ini, kesan medan magnet dan MPAC terhadap pembentukan awal biogranul dikaji menggunakan satu faktor pada satu masa (OFAT) dan kaedah gerak balas permukaan (RSM). Pembentukkan biogranul kemudiannya dikaji menggunakan dua reaktor kumpulan sesekumpul (SBR) berskala makmal dalam keadaan berselang seli bagi fasa anaerobik dan aerobik. Reaktor R1 bertindak sebagai sistem kawalan manakala Reaktor R2 ditambah dengan MPAC. Reaktor ini direka untuk beroperasi dengan jumlah isipadu 3 L dan dikendalikan dengan kadar sisa pertukaran isipadu (VER) 50%. Biogranul ini dihasilkan dengan menggunakan campuran enapcemar dari kilang tekstil dan sistem rawatan air sisa bandaran. Sistem ini dijalankan dengan air sisa tekstil sintetik. Prestasi penyingkiran, aspek struktur dan pembentukan biogranul MPAC telah dikaji berdasarkan sifat fizikal, biologi dan kimia. Keputusan kajian kelompok menunjukkan induksi medan magnet statik dan MPAC memberikan kesan positif yang signifikan untuk meningkatkan proses pembentukkan biogranulasi di peringkat awal. Selepas 60 hari pembentukkan, saiz purata biogranul meningkat dan mencapai 2.0 mm ± 0.5 dengan halaju enapan 44 m/j dengan indeks isipadu enapcemar (SVI) 34 mL/g. Jumlah kepekatan biomas adalah 8.2 g/L, yang mana diperhatikan memberi kelebihan kepada prestasi sistem. Analisis kadar pengambilan oksigen (OUR) menunjukkan kehadiran bakteria fakultatif, anaerobik dan aerobik di dalam biogranul yang dihasilkan. Bahan polimer ekstraselular (EPS) daripada biogranul baru yang dihasilkan juga diukur dalam kajian ini. Jumlah kandungan EPS untuk biogranul ini adalah 0.083 g. Sistem SBR yang mengandungi biogranul MPAC menunjukkan prestasi penyingkiran yang baik apabila dikendalikan dengan masa tahanan hidraul (HRT) 24 jam dengan reaksi anaerobik (18 jam) dan reaksi aerobik (6 jam). Prestasi penyingkiran tertinggi untuk warna, ammonia, TOC dan COD masing-masing adalah 83%, 98%, 95% dan 97%. Tahap akhir kajian ini melibatkan pembentukan model *Artificial Neural Network* (ANN) untuk meramalkan prestasi biogranul di HRT dan fasa tindak balas yang berbeza. Model ANN telah berjaya meramalkan prestasi penyingkiran warna dengan regresi (R^2) 0.9923 dan ralat min kuasa dua (MSE) $2.75e^{-05}$. Kajian ini menunjukkan bahawa penambahan MPAC dalam pembentukkan biogranul menunjukkan penambahbaikan yang signifikan dalam ciri fizikal, biologi dan kimia bagi biogranul yang baru dihasilkan. Penambahan MPAC dapat memendekkan masa dan meningkatkan pembentukan biogranulasi di mana MPAC bertindak sebagai media sokongan untuk pembiakan mikrob semasa pembentukan biogranul.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

16S rRNA	-	16 subunit ribosomal ribonucleic acid
ADMI	-	American Dye Manufacturing Index
Ag	-	Aggregation (%)
ANN	-	Artificial Neural Network
ANOVA	-	Analysis of variance
APHA	-	American Public Health Association
BSA	-	Bovine serum albumin
CCD	-	Central Composite Design
COD	-	Chemical oxygen demand (mg/L)
DGGE	-	Denaturing gradient gel electrophoresis
DO	-	Dissolved oxygen (mg/L)
EPS	-	Extracellular polymeric substances
FISH	-	Fluorescent *in situ* hybridization
FESEM	-	Field-Emission Scanning Electron Microscope
HRT	-	Hydraulic retention time (h)
IC	-	Integrity coefficient (%)
IPC	-	Integrated pollution control
IWK	-	Indah Water Konsortium
LOFT	-	Lack of fit test
LB-EPS	-	Loosely-bound Extra-cellular polymeric substances
MPAC	-	Magnetic powder activated carbon
MSE	-	Mean square error
MLSS	-	Mixed liquor suspended solid (mg/L)
MLVSS	-	Mixed liquor volatile suspended solid (mg/L)
MWTP	-	Municipal wastewater treatment plan
OLR	-	Organic loading rate (kg/m^3·day)
OUR	-	Oxygen uptake rate (mg/L.h)
PN	-	Exoprotein
PS	-	Polysaccharide

RG	-	Residual granules (mg)
RSM	-	Response surface method
SAV	-	Superficial air velocity (cm/s)
SBR	-	Sequencing batch reactor
SMF	-	Static Magnetic Field
SG	-	Settled granules (mg)
SV	-	Settling velocity (cm/s)
SHb	-	Surface hydrophobicity
SRT	-	Sludge retention time (day)
SVI	-	Sludge volume index (mL/g)
STP	-	Sewage treatment plant
SS	-	Suspended solid
SOUR	-	Specific oxygen uptake rate
TB-EPS	-	Tightly-bound Extra-cellular polymeric substances
TOC	-	Total organic carbon (mg/L)
UV-Vis	-	Ultraviolet visible spectroscopy
VER	-	Volumetric exchange rate
WW	-	Wastewater
WWTP	-	Wastewater treatment plant

LIST OF SYMBOLS

^oC	-	Celsius
R^2	-	Coefficient of determination
T_i	-	Turbidity influent (initial)
T_f	-	Turbidity effluent (final)

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

The rapid population growth and industrialization has caused an increase on the volume of wastewater disposed into the environment. Industrialization in the textile industry is synonymous with the consumption of large volume of water which is subsequently disposed as wastewater containing high load pollutants. These pollutants can cause contamination to water body if there are not properly eliminated from wastewater.

Several treatment technologies can be utilized for textile wastewater treatment. In Malaysia, most industrial effluents are treated with conventional wastewater treatment processes involving physical, chemical and biological techniques. Most treatment plants use single or combined biological treatment process comprising of aerobic, anoxic and anaerobic systems. Application of physical and chemical processes in these treatment plants are hindered by their associated capital and operational cost (Holkar et al, 2016). Furthermore, excessive application of chemical during treatment can cause secondary pollution. Some of the treatment systems can potentially remove color from wastewater while most treatment processes transform contaminants into different forms. According to Integrated Pollution Control (IPC) regulation, decoloration systems that transfer pollutants between environments are prohibited (Willmott et al, 1998).

Biogranulation technology is one of the great achievements in biological wastewater treatment of the twentieth century. It is a compact and dense microbial aggregate formed through self-microbial immobilization involving physical, chemical and biological processes (Liu and Tay, 2004). Biogranules are differentiated from conventional activated sludge systems by their regular shape, dense nature, strong microbial structure and good settleability (Zheng et al, 2006). This biogranules consist millions of microorganism that clump together with anaerobic microorganism occupying the inner layer and aerobic microbe at the outer layer of the biogranules. The presence of both types of microorganisms in the granules makes biogranulation a suitable technology for the complete biodegradation of textile wastewater.

Biogranules are usually developed using sequencing batch reactors (SBR) with cycle configuration strictly regulated for rapid settling and frequent repetition of feast and famine condition. This configuration supports the growth of dense and stable biogranules. However, studies have shown that properties of biogranules developed in SBR are affected to several factors including organic loading rate, substrate composition, feast-famine regime, hydrodynamic shear force, feeding strategy, reactor configuration, dissolved oxygen (DO), cycle time, volume exchange ratio, solids retention time and settling time.

1.2 Problem Statement

Biogranules application in wastewater treatment is considered as promising alternative in biotechnology. Biogranulation is associated with several advantages such as high settling velocity and strong microbial structure which causes high sludge retention and tolerate higher loading rates from high strength wastewater. The characteristic of biogranules that have various types of microorganisms would able to perform both aerobic and anaerobic degradation process in a single reactor column makes biogranulation technology suitable for degradation of textile wastewater. Textile wastewater is known as a complex chemical structure and studies have shown that complete mineralization of dye compound in textile wastewater required both anaerobic and aerobic biological approaches (Melgoza et al, 2004). Hence, biogranulation systems seem to be a suitable biological treatment approach that may be able to perform a complete and effective degradation process for textile wastewater.

However, the long start-up period and instability of the reactor system under long SBR operation has been the major drawback of granulation technology. In order to enhance fast biogranulation process and as well as to enhance the stability of biogranules, many attempts have been conducted by adding various types of substances during development of biogranules such as granular activated carbon (Li et al, 2012; Zhou et al, 2015; Tao et al, 2017), zeolite (Wei et al, 2012), dry sewage sludge micropowder (Li et al, 2015), yellow earth (He et al, 2016) and magnetic nanoparticles (Liang et al, 2017). The use of these materials increases the aggregation percentage of microorganisms by acting as nuclei during biogranules development (Li et al, 2015). Previous research reported that static magnetic field able to enhance biogranulation development (Wang et al, 2012; Liu et al, 2016). Then several attempts have been made to enhance growth of microbes using magnetic field induction (Nakamura et al, 1997; Motta et al, 2001; Muniz et al, 2007; Novak et al, 2007, Tu et al, 2015) and increase EPS production (Wang et al, 2012).

However, the effect of SMF on the start-up period of the bioreactor, aggregation, hydrophobicity, settleability and flocculation ability of microbial granules was not much reported. The application of specific carriers acted together with magnetized sludge on the biogranules development process is very much lacking. In particularly, there is lack of information relating to the effect of SMF and specific carriers on EPS production and biogranules development. Thus, a comprehensive study on the application of specific carriers and SMF in the development of biogranules is needed.

This study proposed a different approach to accelerating the biogranulation process. The magnetic powder activated carbon (MPAC) was evaluated as a potential enhancer of biogranulation development process. The system utilized the concept of sequential anaerobic and aerobic biological reactions for complete degradation of textile wastewater. Furthermore, magnetic field concept was used to initiate and enhance the initial granulation stage. The newly formed biogranules were characterized and their performance evaluated for its performance in order to observe the impact of the addition of magnetic powder activated carbon onto biogranules.

1.3 Objectives of the Study

The objective of this study are:

i. To investigate the effect of static magnetic field and magnetic powder activated carbon at the initial stage of biogranulation development through batch study.

ii. To develop biogranules with the addition of magnetic powder activated carbon and characterizes the newly developed biogranules for its physical, chemical and biological properties.

iii. To investigate the removal performance of the enhanced biogranulation system during the development and post-development stage.

iv. To develop an artificial neural network (ANN) model for prediction of color removal performance of MPAC biogranules.

1.4 Scope of the Study

This study covers the design and application of batch test experiment and a laboratory-scale reactor system that are based on the sequential batch reactor system. All of the experiments were conducted in Environmental Laboratory, School of Civil Engineering, Universiti Teknologi Malaysia (UTM).

Initially batch experiments were carried out to investigate the effect of magnetic field intensity and MPAC concentration on the aggregation and surface hydrophobicity. Then, biogranules were developed using synthetic textile wastewater with combination of MPAC. The cultivation of biogranules was investigated using two laboratory scale SBR under intermittent anaerobic and aerobic conditions. The SBR were operated in parallel with Reactor R1 as control and Reactor R2 containing of MPAC. During development process, samples of biogranules were collected and examined. The physical, chemical and biological properties of matured biogranules were characterized. The reactor performances for post-development were studied based on COD, TOC, ammonia and color removal. Dye degradation in the treated wastewater was measured using ultraviolet visible spectroscopy (UV-Vis). Furthermore, field-emission scanning electron microscope analysis (FESEM) was used to inspect the microstructural characteristics of matured biogranules. The study also included analysis of extracellular polymeric substances (EPS) of biogranules. EPS compositions consist of proteins, polysaccharides and carbohydrates were determined in this study. Finally, an artificial neural network (ANN) model was developed to predict the performance of MPAC biogrnaules in term of color removal.

1.5 Significance of the Study

Biogranulation technology is a promising method for wastewater treatment due to its low operational and investment cost as well as small space requirement (Liu et al, 2010). Recently, various approaches have been used by to improve the startup period of biogranules. Improving the initial biogranulation development stage could enhance the efficiency of biogranules. However, the influence of magnetic field combined with magnetic activated carbon is not yet evaluated. There is a lack of information on the effect of magnetic field and magnetic activated carbon on biogranules development. Therefore, the significance of this study can be listed as follows.

i. The study investigates the effect of magnetic field (intensity 0-30 mT) on aggregation, surface hydrophobicity and COD performance of activated sludge. It further examines the impact of magnetic activated carbon on activated sludge for initial biogranules development. The findings would provide knowledge on suitable conditions for the development of the MPAC biogranules

REFERENCES

Ab Halim, M. H., Anuar, A. N., Azmi, S. I., Jamal, N. S. A., Wahab, N. A., Ujang, Z., . . . Bob, M. M. (2015). Aerobic sludge granulation at high temperatures for domestic wastewater treatment. *Bioresource technology, 185*, 445-449.

Adav, S. S., Chen, M. Y., Lee, D. J., & Ren, N. Q. (2007). Degradation of phenol by aerobic granules and isolated yeast Candida tropicalis. *Biotechnology and Bioengineering, 96*(5), 844-852.

Adav, S. S., Lee, D.-J., & Lai, J.-Y. (2008). Intergeneric coaggregation of strains isolated from phenol-degrading aerobic granules. *Applied microbiology and biotechnology, 79*(4), 657-661.

Adav, S. S., & Lee, D.-J. (2008). Extraction of extracellular polymeric substances from aerobic granule with compact interior structure. *Journal of hazardous materials, 154*(1-3), 1120-1126.

Alimi, F., Tlili, M., Amor, M. B., Maurin, G., & Gabrielli, C. (2009). Effect of magnetic water treatment on calcium carbonate precipitation: Influence of the pipe material. *Chemical Engineering and Processing: Process Intensification, 48*(8), 1327-1332.

Alphenaar, P. A., Visser, A., & Lettinga, G. (1993). The effect of liquid upward velocity and hydraulic retention time on granulation in UASB reactors treating wastewater with a high sulphate content. *Bioresource technology, 43*(3), 249-258.

Alves, M., Cavaleiro, A. J., Ferreira, E. C., Amaral, A. L., Mota, M., da Motta, M., . . . Pons, M.-N. (2000). Characterisation by image analysis of anaerobic sludge under shock conditions. *Water Science and Technology, 41*(12), 207-214.

Apha, A. WPCF.(2005). *Standard Methods For Examination of Water And Wastewater, 21th. Ed. New York: APHA, AWWA, WPCR, 1*.

Aquino, S., & Stuckey, D. (2004). The effect of organic and hydraulic shock loads on the production of soluble microbial products in anaerobic digesters. *Water Environment Research, 76*(7), 2628-2636.

Arrojo, B., Mosquera-Corral, A., Garrido, J. M., & Méndez, R. (2004). Aerobic granulation with industrial wastewater in sequencing batch reactors. *Water research, 38*(14-15), 3389-3399.

BABU, B. R., PARANDE, A., RAGHU, S. & KUMAR, T. P. 2007. Cotton textile processing: waste generation and effluent treatment. *Journal of cotton science*.

Bachmann, A., Beard, V. L., & McCarty, P. L. (1985). Performance characteristics of the anaerobic baffled reactor. *Water research, 19*(1), 99-106.

Badireddy, A. R., Chellam, S., Yanina, S., Gassman, P., & Rosso, K. M. (2008). Bismuth dimercaptopropanol (BisBAL) inhibits the expression of extracellular polysaccharides and proteins by Brevundimonas diminuta: implications for membrane microfiltration. *Biotechnology and Bioengineering, 99*(3), 634-643.

Badireddy, A. R., Chellam, S., Gassman, P. L., Engelhard, M. H., Lea, A. S., & Rosso, K. M. (2010). Role of extracellular polymeric substances in bioflocculation of activated sludge microorganisms under glucose-controlled conditions. *Water research, 44*(15), 4505-4516.

Baker, J. S., & Judd, S. J. (1996). Magnetic amelioration of scale formation. *Water research, 30*(2), 247-260.

Barr, J. J., Cook, A. E., & Bond, P. L. (2010). Granule formation mechanisms within an aerobic wastewater system for phosphorus removal. *Applied and environmental microbiology, 76*(22), 7588-7597.

Bashiri, B., Fallah, N., Bonakdarpour, B., & Elyasi, S. (2018). The development of aerobic granules from slaughterhouse wastewater in treating real dyeing wastewater by Sequencing Batch Reactor (SBR). *Journal of Environmental Chemical Engineering*.

Belyavskaya, N. (2004). Biological effects due to weak magnetic field on plants. *Advances in space Research, 34*(7), 1566-1574.

Bernardin, J. D., & Chan, S. (1991). Magnetic effects on simulated brine properties pertaining to magnetic water treatment. *American Society of Mechanical Engineers, Heat Transfer Division,(Publication) HTD., 164*, 109-117.

Beun, J., Hendriks, A., Van Loosdrecht, M., Morgenroth, E., Wilderer, P., & Heijnen, J. (1999). Aerobic granulation in a sequencing batch reactor. *Water research, 33*(10), 2283-2290.

Beun, J., Van Loosdrecht, M., & Heijnen, J. (2000). Aerobic granulation. *Water Science and Technology, 41*(4-5), 41-48.

Beun, J., Van Loosdrecht, M., & Heijnen, J. (2002). Aerobic granulation in a sequencing batch airlift reactor. *Water research, 36*(3), 702-712.

Blanchard, J., & Blackman, C. (1994). Clarification and application of an ion parametric resonance model for magnetic field interactions with biological systems. *Bioelectromagnetics: Journal of the Bioelectromagnetics Society, The Society for Physical Regulation in Biology and Medicine, The European Bioelectromagnetics Association, 15*(3), 217-238.

Blank, M. (1995). Electromagnetic fields(biological interactions and mechanisms). *Advances in chemistry series*.

Bruk, O., Klassen, V., & Krylov, O. (1987). Mechanism of magnetic treatment of disperse system. *Soviet Surface Engineering Application and Electrochemical (Electronmaya Obrabotca Materiolov), 6*, 45-50.

Canzi, E., Guglielmetti, S., Mora, D., Tamagnini, I., & Parini, C. (2005). Conditions affecting cell surface properties of human intestinal bifidobacteria. *Antonie Van Leeuwenhoek, 88*(3), 207-219.

CARMEN, Z. & DANIELA, S. Textile organic dyes–characteristics, polluting effects and separation/elimination procedures from industrial effluents–a critical overview. Organic pollutants ten years after the Stockholm convention-environmental and analytical update, 2012. IntechOpen.

Cassidy, M., Lee, H., & Trevors, J. (1996). Environmental applications of immobilized microbial cells: a review. *Journal of Industrial Microbiology, 16*(2), 79-101.

Chin, C.-J. M., Chen, P.-W., & Wang, L.-J. (2006). Removal of nanoparticles from CMP wastewater by magnetic seeding aggregation. *Chemosphere, 63*(10), 1809-1813.

Chen, Y., Jiang, W., Liang, D. T., & Tay, J. H. (2007a). Structure and stability of aerobic granules cultivated under different shear force in sequencing batch reactors. *Applied microbiology and biotechnology, 76*(5), 1199-1208.

Chen, M., Lee, D., & Tay, J. (2007b). Distribution of extracellular polymeric substances in aerobic granules. *Applied microbiology and biotechnology, 73*(6), 1463-1469.

Chen, Y., Jiang, W., Liang, D. T., & Tay, J. H. (2008). Aerobic granulation under the combined hydraulic and loading selection pressures. *Bioresource technology, 99*(16), 7444-7449.

Chen, Y.-P., Zhang, P., Guo, J.-S., Fang, F., Gao, X., & Li, C. (2013). Functional groups characteristics of EPS in biofilm growing on different carriers. *Chemosphere, 92*(6), 633-638.

Colic, M., & Morse, D. (1999). The elusive mechanism of the magnetic 'memory'of water. *Colloids and Surfaces A: Physicochemical and Engineering Aspects, 154*(1-2), 167-174.

Coma, M., Verawaty, M., Pijuan, M., Yuan, Z., & Bond, P. (2012). Enhancing aerobic granulation for biological nutrient removal from domestic wastewater. *Bioresource technology, 103*(1), 101-108.

Costerton, J. W., Lewandowski, Z., Caldwell, D. E., Korber, D. R., & Lappin-Scott, H. M. (1995). Microbial biofilms. *Annual Reviews in Microbiology, 49*(1), 711-745.

CZARNOTA, J., MASŁOŃ, A. & ZDEB, M. Powdered keramsite as unconventional method of AGS technology support in GSBR reactor with minimum-optimum OLR. E3S Web of Conferences, 2018. EDP Sciences, 00024.

Dahalan, F. A., Abdullah, N., Yuzir, A., Olsson, G., Hamdzah, M., Din, M. F. M., . . . Noor, Z. Z. (2015). A proposed aerobic granules size development scheme for aerobic granulation process. *Bioresource technology, 181*, 291-296.

Dangcong, P., Bernet, N., Delgenes, J.-P., & Moletta, R. (1999). Aerobic granular sludge—a case report. *Water research, 33*(3), 890-893.

De Kreuk, M., Heijnen, J., & Van Loosdrecht, M. (2005a). Simultaneous COD, nitrogen, and phosphate removal by aerobic granular sludge. *Biotechnology and Bioengineering, 90*(6), 761-769.

De Kreuk, M., Pronk, M., & Van Loosdrecht, M. (2005b). Formation of aerobic granules and conversion processes in an aerobic granular sludge reactor at moderate and low temperatures. *Water research, 39*(18), 4476-4484.

De Kreuk, M., Kishida, N., & Van Loosdrecht, M. (2007). Aerobic granular sludge–state of the art. *Water Science and Technology, 55*(8-9), 75-81.

Rollemberg de Sousa, S. L., Barros, A. R. M., Firmino, P. I. M., & dos Santos, A. B. (2018). Aerobic granular sludge: Cultivation parameters and removal mechanisms. *Bioresource technology*.

De Vicente, I., Merino-Martos, A., Guerrero, F., Amores, V., & de Vicente, J. (2011). Chemical interferences when using high gradient magnetic separation for phosphate removal: Consequences for lake restoration. *Journal of hazardous materials, 192*(3), 995-1001.

Di Iaconi, C., Ramadori, R., Lopez, A., & Passino, R. (2007). Aerobic granular sludge systems: the new generation of wastewater treatment technologies. *Industrial & engineering chemistry research, 46*(21), 6661-6665.

Dubois, M., Gilles, K. A., Hamilton, J. K., Rebers, P. t., & Smith, F. (1956). Colorimetric method for determination of sugars and related substances. *Analytical chemistry, 28*(3), 350-356.

Etterer, T., & Wilderer, P. (2001). Generation and properties of aerobic granular sludge. *Water Science and Technology, 43*(3), 19-26.

Fang, H. H., Liu, H., & Zhang, T. (2002). Characterization of a hydrogen‐ producing granular sludge. *Biotechnology and Bioengineering, 78*(1), 44-52.

Figueroa, M., Mosquera-Corral, A., Campos, J., & Méndez, R. (2008). Treatment of saline wastewater in SBR aerobic granular reactors. *Water Science and Technology, 58*(2), 479-485.

Figueroa, M., Val del Rio, A., Campos, J., Mosquera-Corral, A., & Mendez, R. (2011). Treatment of high loaded swine slurry in an aerobic granular reactor. *Water Science and Technology, 63*(9), 1808-1814.

Flemming, H.-C., Neu, T. R., & Wozniak, D. J. (2007). The EPS matrix: the "house of biofilm cells". *Journal of bacteriology, 189*(22), 7945-7947.

Florestano, E., Marchello, J., & Bhat, S. (1996). Magnetic water treatment in lieu of chemicals. *Chemical Engineering World, 31*, 133-140.

Florez, M., Carbonell, M. V., & Martínez, E. (2007). Exposure of maize seeds to stationary magnetic fields: Effects on germination and early growth. *Environmental and experimental botany, 59*(1), 68-75.

Foster, H. A., Ditta, I. B., Varghese, S., & Steele, A. (2011). Photocatalytic disinfection using titanium dioxide: spectrum and mechanism of antimicrobial activity. *Applied microbiology and biotechnology, 90*(6), 1847-1868.

Franca, R. D., Vieira, A., Mata, A. M., Carvalho, G. S., Pinheiro, H. M., & Lourenço, N. D. (2015). Effect of an azo dye on the performance of an aerobic granular sludge sequencing batch reactor treating a simulated textile wastewater. *Water research, 85*, 327-336.

Frølund, B., Palmgren, R., Keiding, K., & Nielsen, P. H. (1996). Extraction of extracellular polymers from activated sludge using a cation exchange resin. *Water research, 30*(8), 1749-1758.

Geesey, G. (1982). Microbial exopolymers: ecological and economic considerations. *Am Soc Microbiol News, 48*, 9-14.

Ghaly, A., Ananthashankar, R., Alhattab, M. & Ramakrishnan, V. 2014. Production, characterization and treatment of textile effluents: a critical review. J Chem Eng Process Technol, 5, 1-19.

Ghangrekar, M., Asolekar, S., & Joshi, S. (2005). Characteristics of sludge developed under different loading conditions during UASB reactor start-up and granulation. *Water research, 39*(6), 1123-1133.

Grady Jr, C. L., & Glen, T. (1999). Daigger., Henry C. Lim."Biological Wastewater Treatment second Edition", Revised and Expanded. *ed: Marcel Dekker, Inc. New York Basel*.

Guo, F., Zhang, S.-H., Yu, X., & Wei, B. (2011). Variations of both bacterial community and extracellular polymers: the inducements of increase of cell hydrophobicity from biofloc to aerobic granule sludge. *Bioresource technology*, *102*(11), 6421-6428.

Hailei, W., Guangli, Y., Guosheng, L., & Feng, P. (2006). A new way to cultivate aerobic granules in the process of papermaking wastewater treatment. *Biochemical engineering journal, 28*(1), 99-103.

Hao, X. L., Zou, L. Y., Zhang, G. S., & Zhang, Y. B. (2009). Magnetic field assisted Fenton reactions for the enhanced degradation of methyl blue. *Chinese Chemical Letters*, *20*(1), 99-101.

Hattori, S., Watanabe, M., Endo, T., Togii, H., & Sasaki, K. (2001). Effects of an external magnetic field on the sedimentation of activated sludge. *World Journal of Microbiology and Biotechnology*, *17*(3), 279-285.

Hattori, S., Watanabe, M., Osono, H., Togii, H., & Sasaki, K. (2001). Effects of an external magnetic field on the flock size and sedimentation of activated sludge. *World Journal of Microbiology and Biotechnology*, *17*(9), 833-838.

He, Q., Zhang, S., Zou, Z., & Wang, H. (2016). *Enhanced formation of aerobic granular sludge with yellow earth as nucleating agent in a sequencing batch* *reactor*. Paper presented at the IOP Conference Series: Earth and Environmental Science.

Hecht-Nielsen, R. (1990). On the algebraic structure of feedforward network weight spaces *Advanced Neural Computers* (pp. 129-135): Elsevier.

Heijnen, J., & van Loosdrecht, M. (1998). Method for Acquiring Grain-shaped Growth of a Microorganism in a Reactor: European Patent. *EP0826639*.

Higashitani, K., Kage, A., Katamura, S., Imai, K., & Hatade, S. (1993). Effects of a magnetic field on the formation of CaCO3 particles. *Journal of colloid and interface science, 156*(1), 90-95.

Hu, X., Dong, H.-Y., Qiu, Z.-N., Qian, G.-R., Ye, L., Zhu, H.-c., & Ren, Z.-M. (2007). The effect of high magnetic field characterized by kinetics: Enhancing the biodegradation of acid red 1 with a strain of Bacillus sp. *International Biodeterioration & Biodegradation, 60*(4), 293-298.

Huang, L., Yang, T., Wang, W., Zhang, B., & Sun, Y. (2012). Effect of Mn 2+ augmentation on reinforcing aerobic sludge granulation in a sequencing batch reactor. *Applied microbiology and biotechnology, 93*(6), 2615-2623.

Holkar, C. R., Jadhav, A. J., Pinjari, D. V., Mahamuni, N. M., & Pandit, A. B. (2016). A critical review on textile wastewater treatments: possible approaches. *Journal of environmental management, 182*, 351-366.

Irkia, S., Ghernaout, D., & Naceura, M. W. (2017). Decolourization of Methyl Orange (MO) by electrocoagulation (EC) using iron electrodes under a magnetic field (MF). *Desalination and Water Treatment, 79*, 368-377.

Ibrahim, S. A., Hassan, O., Salameh, M., & Shahbazi, A. (2005). Effect of media composition and incubation temperatures on autoaggregation behavior of bifidobacteria. *Milchwissenschaft, 60*(2), 127-129.

Ismail, W., Mokhtar, M. Z., & Ali, A. (2013). Design activities and the difference level of sales and profits performance of the batik SMEs in Malaysia. International Review of Management and Business Research, 2(2), 627-642.

Iwasaka, M., Ikehata, M., Miyakoshi, J., & Ueno, S. (2004). Strong static magnetic field effects on yeast proliferation and distribution. *Bioelectrochemistry, 65*(1), 59-68.

Izano, E. A., Amarante, M. A., Kher, W. B., & Kaplan, J. B. (2008). Differential roles of poly-N-acetylglucosamine surface polysaccharide and extracellular

DNA in Staphylococcus aureus and Staphylococcus epidermidis biofilms. *Applied and environmental microbiology, 74*(2), 470-476.

Jang, A., Yoon, Y.-H., Kim, I. S., Kim, K.-S., & Bishop, P. L. (2003). Characterization and evaluation of aerobic granules in sequencing batch reactor. *Journal of Biotechnology, 105*(1-2), 71-82.

Jemaat, Z., Suárez-Ojeda, M. E., Pérez, J., & Carrera, J. (2014). Partial nitritation and o-cresol removal with aerobic granular biomass in a continuous airlift reactor. *Water research, 48*, 354-362.

Ji, Y., Wang, Y., Sun, J., Yan, T., Li, J., Zhao, T., . . . Sun, C. (2010). Enhancement of biological treatment of wastewater by magnetic field. *Bioresource technology, 101*(22), 8535-8540.

Jiang, H.-L., Tay, J.-H., Liu, Y., & Tay, S. T.-L. (2003). Ca2+ augmentation for enhancement of aerobically grown microbial granules in sludge blanket reactors. *Biotechnology letters, 25*(2), 95-99.

Jiang, H.-L., Tay, J.-H., & Tay, S.-L. (2004). Changes in structure, activity and metabolism of aerobic granules as a microbial response to high phenol loading. *Applied microbiology and biotechnology, 63*(5), 602-608.

Jorand, F., Guicherd, P., Urbain, V., Manem, J., & Block, J. (1994). Hydrophobicity of activated sludge flocs and laboratory-grown bacteria. *Water Science and Technology, 30*(11), 211-218.

Juang, Y.-C., Adav, S. S., Lee, D.-J., & Tay, J.-H. (2010). Stable aerobic granules for continuous-flow reactors: precipitating calcium and iron salts in granular interiors. *Bioresource technology, 101*(21), 8051-8057.

Jung, J., Sanji, B., Godbole, S., & Sofer, S. (1993). Biodegradation of phenol: a comparative study with and without applying magnetic fields. *Journal of Chemical Technology & Biotechnology, 56*(1), 73-76.

Jung, J., & Sofer, S. (1997). Enhancement of phenol biodegradation by south magnetic field exposure. *Journal of Chemical Technology & Biotechnology: International Research in Process, Environmental AND Clean Technology, 70*(3), 299-303.

Kang, A. J., & Yuan, Q. (2017). Long-term stability and nutrient removal efficiency of aerobic granules at low organic loads. *Bioresource technology, 234*, 336-342.

Kara, F., Gurakan, G., & Sanin, F. (2008). Monovalent cations and their influence on activated sludge floc chemistry, structure, and physical characteristics. *Biotechnology and Bioengineering, 100*(2), 231-239.

Karapinar, N. (2003). Magnetic separation of ferrihydrite from wastewater by magnetic seeding and high-gradient magnetic separation. *International Journal of Mineral Processing, 71*(1-4), 45-54.

Khalida Muda, (2010). *Facultative anaerobic granular sludge for textile dyeing wastewater treatment.* Universiti Teknologi Malaysia.

Kim, S.-K., Kong, I., Lee, B.-H., Kang, L., Lee, M.-G., & Suh, K. H. (2000). Removal of ammonium-N from a recirculation aquacultural system using an immobilized nitrifier. *Aquacultural engineering, 21*(3), 139-150.

Kim, I. S., Kim, S.-M., & Jang, A. (2008). Characterization of aerobic granules by microbial density at different COD loading rates. *Bioresource technology, 99*(1), 18-25.

Kishida, N., Tsuneda, S., Kim, J., & Sudo, R. (2009). Simultaneous nitrogen and phosphorus removal from high-strength industrial wastewater using aerobic granular sludge. *Journal of environmental engineering, 135*(3), 153-158.

Kney, A., & Parsons, S. (2006). A spectrophotometer-based study of magnetic water treatment: Assessment of ionic vs. surface mechanisms. *Water research, 40*(3), 517-524.

Kordyum, E., Bogatina, N., Kalinina, Y. M., & Sheykina, N. (2005). A weak combined magnetic field changes root gravitropism. *Advances in space Research, 36*(7), 1229-1236.

Kovacs, P. E., Valentine, R. L., & Alvarez, P. J. (1997). The effect of static magnetic fields on biological systems: implications for enhanced biodegradation. *Critical reviews in environmental science and technology, 27*(4), 319-382.

Krzemieniewski, M., Debowski, M., Janczukowicz, W., & Pesta, J. (2004). Effect of the Constant Magnetic Field on the Composition of Dairy Wastewater and and W Domestic Sewage. *Polish Journal of Environmental Studies, 13*(1), 45-53.

Kwok, W., Picioreanu, C., Ong, S., Van Loosdrecht, M., Ng, W., & Heijnen, J. (1998). Influence of biomass production and detachment forces on biofilm structures in a biofilm airlift suspension reactor. *Biotechnology and Bioengineering, 58*(4), 400-407.

Laspidou, C. S., & Rittmann, B. E. (2002). A unified theory for extracellular polymeric substances, soluble microbial products, and active and inert biomass. *Water research, 36*(11), 2711-2720.

Lazarova, V., & Manem, J. (1995). Biofilm characterization and activity analysis in water and wastewater treatment. *Water research, 29*(10), 2227-2245.

Lebkowska, M., Rutkowska-Narozniak, A., Pajor, E., & Pochanke, Z. (2011). Effect of a static magnetic field on formaldehyde biodegradation in wastewater by activated sludge. *Bioresour Technol, 102*(19), 8777-8782.

Lee, D.-J., Chen, Y.-Y., Show, K.-Y., Whiteley, C. G., & Tay, J.-H. (2010). Advances in aerobic granule formation and granule stability in the course of storage and reactor operation. *Biotechnology advances, 28*(6), 919-934.

Lettinga, G., Van Velsen, A., Hobma, S. d., De Zeeuw, W., & Klapwijk, A. (1980). Use of the upflow sludge blanket (USB) reactor concept for biological wastewater treatment, especially for anaerobic treatment. *Biotechnology and Bioengineering, 22*(4), 699-734.

Lettinga, G., Field, J., Van Lier, J., Zeeman, G., & Pol, L. H. (1997). Advanced anaerobic wastewater treatment in the near future. *Water Science and Technology, 35*(10), 5-12.

Li, Z., Kuba, T., & Kusuda, T. (2006). The influence of starvation phase on the properties and the development of aerobic granules. *Enzyme and Microbial Technology, 38*(5), 670-674.

Li, X. Y., & Yang, S. (2007). Influence of loosely bound extracellular polymeric substances (EPS) on the flocculation, sedimentation and dewaterability of activated sludge. *Water research, 41*(5), 1022-1030.

Li, A.-j., Yang, S.-f., Li, X.-y., & Gu, J.-d. (2008). Microbial population dynamics during aerobic sludge granulation at different organic loading rates. *Water research, 42*(13), 3552-3560.

Li, X.-M., Liu, Q.-Q., Yang, Q., Guo, L., Zeng, G.-M., Hu, J.-M., & Zheng, W. (2009). Enhanced aerobic sludge granulation in sequencing batch reactor by Mg2+ augmentation. *Bioresource technology, 100*(1), 64-67.

Li, A.-j., Li, X.-y., & Yu, H.-q. (2011a). Granular activated carbon for aerobic sludge granulation in a bioreactor with a low-strength wastewater influent. *Separation and Purification Technology, 80*(2), 276-283.

Li, X., Xiao, Y., Liao, D., Zheng, W., Yi, T., Yang, Q., & Zeng, G. (2011b). Granulation of simultaneous partial nitrification and anammox biomass in one single SBR system. *Applied biochemistry and biotechnology, 163*(8), 1053-1065.

Li, A.-j., Li, X.-y., & Yu, H.-q. (2012). Aerobic sludge granulation facilitated by activated carbon for partial nitrification treatment of ammonia-rich wastewater. *Chemical Engineering Journal*.

Li, J., Ding, L.-B., Cai, A., Huang, G.-X., & Horn, H. (2014). Aerobic sludge granulation in a full-scale sequencing batch reactor. *BioMed research international, 2014*.

Li, J., Liu, J., Wang, D., Chen, T., Ma, T., Wang, Z., & Zhuo, W. (2015). Accelerating Aerobic Sludge Granulation by Adding Dry Sewage Sludge Micropowder in Sequencing Batch Reactors. *International journal of environmental research and public health, 12*(8), 10056-10065.

Liang, X.-Y., Gao, B.-Y., & Ni, S.-Q. (2017). Effects of magnetic nanoparticles on aerobic granulation process. *Bioresource technology, 227*, 44-49.

Liao, B., Allen, D., Droppo, I., Leppard, G., & Liss, S. (2001). Surface properties of sludge and their role in bioflocculation and settleability. *Water research, 35*(2), 339-350.

Linlin, H., Jianlong, W., Xianghua, W., & Yi, Q. (2005). The formation and characteristics of aerobic granules in sequencing batch reactor (SBR) by seeding anaerobic granules. *Process Biochemistry, 40*(1), 5-11.

Liu, Y., & Tay, J.-H. (2001). Strategy for minimization of excess sludge production from the activated sludge process. *Biotechnology advances, 19*(2), 97-107.

Liu, Y., & Tay, J.-H. (2002). The essential role of hydrodynamic shear force in the formation of biofilm and granular sludge. *Water research, 36*(7), 1653-1665.

Liu, Y., Yang, S.-F., Liu, Q.-S., & Tay, J.-H. (2003a). The role of cell hydrophobicity in the formation of aerobic granules. *Current Microbiology, 46*(4), 0270-0274.

Liu, Y., & Fang, H. H. (2003b). Influences of extracellular polymeric substances (EPS) on flocculation, settling, and dewatering of activated sludge.

Liu, Y., & Tay, J.-H. (2004a). State of the art of biogranulation technology for wastewater treatment. *Biotechnology advances, 22*(7), 533-563.

Liu, Y.-Q., Liu, Y., & Tay, J.-H. (2004b). The effects of extracellular polymeric substances on the formation and stability of biogranules. *Applied microbiology and biotechnology, 65*(2), 143-148.

Liu, Y., Wang, Z.-W., Qin, L., Liu, Y.-Q., & Tay, J.-H. (2005). Selection pressure-driven aerobic granulation in a sequencing batch reactor. *Applied microbiology and biotechnology, 67*(1), 26-32.

Liu, Y.-Q., & Tay, J.-H. (2007). Characteristics and stability of aerobic granules cultivated with different starvation time. *Applied microbiology and biotechnology, 75*(1), 205-210.

Liu, Y., Wang, F., Xia, S., & Zhao, J. (2008). Study of 4-t-octylphenol degradation and microbial community in granular sludge. *Journal of Environmental Sciences, 20*(2), 167-171.

Liu, X.-W., Sheng, G.-P., & Yu, H.-Q. (2009). Physicochemical characteristics of microbial granules. *Biotechnology advances, 27*(6), 1061-1070.

Liu, Y.-Q., Moy, B., Kong, Y.-H., & Tay, J.-H. (2010a). Formation, physical characteristics and microbial community structure of aerobic granules in a pilot-scale sequencing batch reactor for real wastewater treatment. *Enzyme and Microbial Technology, 46*(6), 520-525.

Liu, L., Gao, D.-W., Zhang, M., & Fu, Y. (2010b). Comparison of Ca2+ and Mg2+ enhancing aerobic granulation in SBR. *Journal of hazardous materials, 181*(1-3), 382-387.

Liu, Y.-Q., Kong, Y., Tay, J.-H., & Zhu, J. (2011). Enhancement of start-up of pilot-scale granular SBR fed with real wastewater. *Separation and Purification Technology, 82*, 190-196.

Liu, Y., Kang, X., Li, X., & Yuan, Y. (2015). Performance of aerobic granular sludge in a sequencing batch bioreactor for slaughterhouse wastewater treatment. *Bioresource technology, 190*, 487-491.

Liu, X., Sun, S., Ma, B., Zhang, C., Wan, C., & Lee, D.-J. (2016a). Understanding of aerobic granulation enhanced by starvation in the perspective of quorum sensing. *Applied microbiology and biotechnology, 100*(8), 3747-3755.

Liu, Y., Suhartini, S., Guo, L., & Xiong, Y. (2016b). Improved biological wastewater treatment and sludge characteristics by applying magnetic field to aerobic granules. *AIMS Bioengineering, 3*(4), 412-424.

Long, B., Yang, C.-z., Pu, W.-h., Yang, J.-k., Liu, F.-b., Zhang, L., . . . Cheng, K. (2015). Tolerance to organic loading rate by aerobic granular sludge in a cyclic aerobic granular reactor. *Bioresource technology, 182,* 314-322.

Lowry, O. H., Rosebrough, N. J., Farr, A. L., & Randall, R. J. (1951). Protein measurement with the Folin phenol reagent. *Journal of biological chemistry, 193*(1), 265-275.

Lychagin, N. (1974). Changing properties of magnetized water. *Russian Physics Journal, 17*(2), 229-233.

Mahoney, E., Varangu, L., Cairns, W., Kosaric, N., & Murray, R. G. (1987). The effect of calcium on microbial aggregation during UASB reactor start-up. *Water Science and Technology, 19*(1-2), 249-260.

Manavi, N., Kazemi, A. S., & Bonakdarpour, B. (2017). The development of aerobic granules from conventional activated sludge under anaerobic-aerobic cycles and their adaptation for treatment of dyeing wastewater. *Chemical Engineering Journal, 312*, 375-384.

Mahmod, N., & Wahab, N. A. (2017). Dynamic modelling of aerobic granular sludge artificial neural networks. *International Journal of Electrical and Computer Engineering (IJECE), 7*(3), 1568-1573.

McSwain, B., Irvine, R., & Wilderer, P. (2004). The effect of intermittent feeding on aerobic granule structure. *Water Science and Technology, 49*(11-12), 19-25.

McSwain, B., Irvine, R., Hausner, M., & Wilderer, P. (2005). Composition and distribution of extracellular polymeric substances in aerobic flocs and granular sludge. *Applied and environmental microbiology, 71*(2), 1051-1057.

Meng, F., Zhang, H., Yang, F., Li, Y., Xiao, J., & Zhang, X. (2006). Effect of filamentous bacteria on membrane fouling in submerged membrane bioreactor. *Journal of Membrane Science, 272*(1-2), 161-168.

Miksch, K., & Beata, K. (2012). Distribution of extracellular polymeric substances and their role in aerobic granule formation. *Chemical and Process Engineering, 33*(4), 679-688.

Mishima, K., & Nakamura, M. (1991). Self-immobilization of aerobic activated sludge–a pilot study of the aerobic upflow sludge blanket process in municipal sewage treatment. *Water Science and Technology, 23*(4-6), 981-990.

Mohan, S. V., Rao, N. C., & Sarma, P. (2007). Simulated acid azo dye (Acid black 210) wastewater treatment by periodic discontinuous batch mode operation under anoxic–aerobic–anoxic microenvironment conditions. *Ecological Engineering, 31*(4), 242-250.

Mohammed, R. R., Ketabchi, M. R., & McKay, G. (2014). Combined magnetic field and adsorption process for treatment of biologically treated palm oil mill effluent (POME). *Chemical Engineering Journal, 243*, 31-42.

Morgan, J., Forster, C., & Evison, L. (1990). A comparative study of the nature of biopolymers extracted from anaerobic and activated sludges. *Water research, 24*(6), 743-750.

Morgenroth, E., Sherden, T., Van Loosdrecht, M., Heijnen, J., & Wilderer, P. (1997). Aerobic granular sludge in a sequencing batch reactor. *Water research, 31*(12), 3191-3194.

Mosquera-Corral, A., De Kreuk, M., Heijnen, J., & Van Loosdrecht, M. (2005). Effects of oxygen concentration on N-removal in an aerobic granular sludge reactor. *Water research, 39*(12), 2676-2686.

Motta, M., Montenegro, E., Stamford, T., Silva, A., & Silva, F. (2001). Changes in Saccharomycescerevisiae Development Induced by Magnetic Fields. *Biotechnology progress, 17*(5), 970-973.

Moy, B. P., Tay, J. H., Toh, S. K., Liu, Y., & Tay, S. L. (2002). High organic loading influences the physical characteristics of aerobic sludge granules. *Letters in Applied Microbiology, 34*(6), 407-412.

Muda, K., Aris, A., Salim, M. R., Ibrahim, Z., Yahya, A., van Loosdrecht, M. C., . . . Nawahwi, M. Z. (2010). Development of granular sludge for textile wastewater treatment. *Water research, 44*(15), 4341-4350.

Muniz, J. B., Marcelino, M., Motta, M. d., Schuler, A., & Motta, M. A. d. (2007). Influence of static magnetic fields on S. cerevisae biomass growth. *Brazilian Archives of Biology and Technology, 50*(3), 515-520.

Myoga, H., Asano, H., Nomura, Y., & Yoshida, H. (1991). Effects of immobilization conditions on the nitrification treatability of entrapped cell reactors using the PVA freezing method. *Water Science and Technology, 23*(4-6), 1117-1124.

Nakamura, K., Okuno, K., Ano, T., & Shoda, M. (1997). Effect of high magnetic field on the growth of Bacillus subtilis measured in a newly developed superconducting magnet biosystem. *Bioelectrochemistry and bioenergetics, 43*(1), 123-128.

Nielsen, P. H., & Jahn, A. (1999). Extraction of EPS *Microbial extracellular polymeric substances* (pp. 49-72): Springer.

Nielsen, P. H., Jahn, A., & Palmgren, R. (1997). Conceptual model for production and composition of exopolymers in biofilms. *Water Science and Technology, 36*(1), 11-19.

Niu, C., Liang, W., Ren, H., Geng, J., Ding, L., & Xu, K. (2014). Enhancement of activated sludge activity by 10–50 mT static magnetic field intensity at low temperature. *Bioresource technology, 159*, 48-54.

Novák, J., Strašák, L., Fojt, L., Slaninová, I., & Vetterl, V. (2007). Effects of low-frequency magnetic fields on the viability of yeast Saccharomyces cerevisiae. *Bioelectrochemistry, 70*(1), 115-121.

Oka, T., Kanayama, H., Tanaka, K., Fukui, S., Ogawa, J., Sato, T., . . . Yabuno, R. (2009). Waste water purification by magnetic separation technique using HTS bulk magnet system. *Physica C: Superconductivity, 469*(15-20), 1849-1852.

Ozaki, H., Liu, Z., & Terashima, Y. (1991). Utilization of microorganisms immobilized with magnetic particles for sewage and wastewater treatment. *Water Science and Technology, 23*(4-6), 1125-1136.

Pang, Y. L., & Abdullah, A. Z. (2013). Current status of textile industry wastewater management and research progress in Malaysia: a review. Clean–Soil, Air, Water, 41(8), 751-764.

Park, J.-B., Lee, S.-H., Lee, J.-W., & Lee, C.-Y. (2002). Lab scale experiments for permeable reactive barriers against contaminated groundwater with ammonium and heavy metals using clinoptilolite (01-29B). *Journal of hazardous materials, 95*(1-2), 65-79.

Park, H.-S., Hwang, J.-S., Choi, W.-Y., Shim, D.-S., Na, K.-W., & Choi, S.-O. (2004). Development of micro-fluxgate sensors with electroplated magnetic cores for electronic compass. *Sensors and Actuators A: Physical, 114*(2-3), 224-229.

Park, B.-N., Sohn, Y.-S., & Choi, S.-Y. (2008). Effects of a magnetic field on the copper metallization using the electroplating process. *Microelectronic Engineering, 85*(2), 308-314.

Parsons, S. A., Wang, B.-L., Judd, S. J., & Stephenson, T. (1997). Magnetic treatment of calcium carbonate scale—effect of pH control. *Water research, 31*(2), 339-342.

Pei, H.-y., Hu, W.-r., & Liu, Q.-h. (2010). Effect of protease and cellulase on the characteristic of activated sludge. *Journal of hazardous materials, 178*(1-3), 397-403.

Peyong, Y. N., Zhou, Y., Abdullah, A. Z., & Vadivelu, V. (2012). The effect of organic loading rates and nitrogenous compounds on the aerobic granules developed using low strength wastewater. *Biochemical engineering journal, 67*, 52-59.

Poxon, T. L., & Darby, J. L. (1997). Extracellular polyanions in digested sludge: measurement and relationship to sludge dewaterability. *Water research, 31*(4), 749-758.

Pratt, L. A., & Kolter, R. (1998). Genetic analysis of Escherichia coli biofilm formation: roles of flagella, motility, chemotaxis and type I pili. *Molecular microbiology, 30*(2), 285-293.

Presentatio, F. Fouling Behavior & Nitrogen Removal in The Aerobic Granulation Membrane Bioreactor.

Priester, J. H., Olson, S. G., Webb, S. M., Neu, M. P., Hersman, L. E., & Holden, P. A. (2006). Enhanced exopolymer production and chromium stabilization in Pseudomonas putida unsaturated biofilms. *Applied and environmental microbiology, 72*(3), 1988-1996.

Pushkar, P., & Mungray, A. K. (2016). Real textile and domestic wastewater treatment by novel cross-linked microbial fuel cell (CMFC) reactor. Desalination and Water Treatment, 57(15), 6747-6760.

Qadri, S., Ganoe, A., & Haik, Y. (2009). Removal and recovery of acridine orange from solutions by use of magnetic nanoparticles. *Journal of hazardous materials, 169*(1-3), 318-323.

Qin, L., Liu, Y., & Tay, J.-H. (2004a). Effect of settling time on aerobic granulation in sequencing batch reactor. *Biochemical engineering journal, 21*(1), 47-52.

Qin, L., Tay, J.-H., & Liu, Y. (2004b). Selection pressure is a driving force of aerobic granulation in sequencing batch reactors. *Process Biochemistry, 39*(5), 579-584.

Qin, L., & Liu, Y. (2006). Aerobic granulation for organic carbon and nitrogen removal in alternating aerobic–anaerobic sequencing batch reactor. *Chemosphere, 63*(6), 926-933.

Quarmby, J., & Forster, C. (1995). An examination of the structure of UASB granules. *Water research, 29*(11), 2449-2454.

Rahman, M. M., Kim, W.-S., Kumura, H., & Shimazaki, K.-i. (2008). Autoaggregation and surface hydrophobicity of bifidobacteria. *World Journal of Microbiology and Biotechnology, 24*(8), 1593-1598.

Rajczykowski, K., & Loska, K. (2018). Stimulation of Heavy Metal Adsorption Process by Using a Strong Magnetic Field. *Water, Air, & Soil Pollution, 229*(1), 20.

Ramesh, A., Lee, D.-J., & Hong, S. (2006). Soluble microbial products (SMP) and soluble extracellular polymeric substances (EPS) from wastewater sludge. *Applied microbiology and biotechnology, 73*(1), 219-225.

Ramos, C., Suárez-Ojeda, M. E., & Carrera, J. (2016). Biodegradation of a high-strength wastewater containing a mixture of ammonium, aromatic compounds and salts with simultaneous nitritation in an aerobic granular reactor. *Process Biochemistry, 51*(3), 399-407.

Rosenberg, M., Gutnick, D., & Rosenberg, E. (1980). Adherence of bacteria to hydrocarbons: a simple method for measuring cell-surface hydrophobicity. *FEMS microbiology letters, 9*(1), 29-33.

Rosman, N. H., Anuar, A. N., Chelliapan, S., Din, M. F. M., & Ujang, Z. (2014). Characteristics and performance of aerobic granular sludge treating rubber wastewater at different hydraulic retention time. *Bioresource technology, 161*, 155-161.

Rudd, T., Sterritt, R., & Lester, J. (1984). Formation and conditional stability constants of complexes formed between heavy metals and bacterial extracellular polymers. *Water research, 18*(3), 379-384.

Sala, F. (1999). Magnetic fluids effect upon growth processes in plants. *Journal of magnetism and magnetic materials, 201*(1-3), 440-442.

Salehizadeh, H., & Van Loosdrecht, M. (2004). Production of polyhydroxyalkanoates by mixed culture: recent trends and biotechnological importance. *Biotechnology advances, 22*(3), 261-279.

Sammut, C., & Webb, G. I. (2011). *Encyclopedia of machine learning*: Springer Science & Business Media.

Sarıkaya, M., Abbasov, T., & Erdemoğlu, M. (2006). Some aspects of magnetic filtration theory for removal of fine particles from aqueous suspensions. *Journal of dispersion science and technology, 27*(2), 193-198.

Schmidt, J., & Ahring, B. K. (1994). Extracellular polymers in granular sludge from different upflow anaerobic sludge blanket (UASB) reactors. *Applied microbiology and biotechnology, 42*(2-3), 457-462.

Schwarzenbeck, N., Borges, J., & Wilderer, P. (2005). Treatment of dairy effluents in an aerobic granular sludge sequencing batch reactor. *Applied microbiology and biotechnology, 66*(6), 711-718.

Schwarzenbeck, N., Erley, R., & Wilderer, P. (2003). *Growth of aerobic granular sludge in a SBR-system treating wastewater rich in particulate matter.* Paper presented at the 5th International conference on biofilm systems.

Sesay, M. L., Özcengiz, G., & Sanin, F. D. (2006). Enzymatic extraction of activated sludge extracellular polymers and implications on bioflocculation. *Water research, 40*(7), 1359-1366.

Seviour, T., Pijuan, M., Nicholson, T., Keller, J., & Yuan, Z. (2009). Gel-forming exopolysaccharides explain basic differences between structures of aerobic sludge granules and floccular sludges. *Water research, 43*(18), 4469-4478.

Shen, C., Kosaric, N., & Blaszczyk, R. (1993). The effect of selected heavy metals (Ni, Co and Fe) on anaerobic granules and their extracellular polymeric substance (EPS). *Water research, 27*(1), 25-33.

Sheng, G. P., Yu, H. Q., & Li, X. Y. (2006). Stability of sludge flocs under shear conditions: roles of extracellular polymeric substances (EPS). *Biotechnology and Bioengineering, 93*(6), 1095-1102.

Sheng, G.-P., Yu, H.-Q., & Li, X.-Y. (2010). Extracellular polymeric substances (EPS) of microbial aggregates in biological wastewater treatment systems: a review. *Biotechnology advances, 28*(6), 882-894.

Sobiecka, B. O., Janczukowicz, W., Sobiecki, S., Zieliński, M., & Dębowski, M. (2008). The view of usefulness the hydrogen peroxide (H2O2) and solid magnetic field (SMF) in the COD reduction value in meat industry wastewater. *Pol. J. Nat. Sci, 23*(4), 825-836.

Sombatsompop, K. (2007). Membrane fouling studies in suspended and attached growth membrane bioreactor systems. *A Doctoral Dissertation Thesis*.

Song, Z., Ren, N., Zhang, K., & Tong, L. (2009). Influence of temperature on the characteristics of aerobic granulation in sequencing batch airlift reactors. *Journal of Environmental Sciences, 21*(3), 273-278.

Song, Z., Pan, Y., Zhang, K., Ren, N., & Wang, A. (2010). Effect of seed sludge on characteristics and microbial community of aerobic granular sludge. *Journal of Environmental Sciences(China), 22*(9), 1312-1318.

Spiegel, M. S. (1998). Method and apparatus for applying magnetic fields to fluids: Google Patents.

Su, N., Wu, Y.-H., & Mar, C.-Y. (2000). Effect of magnetic water on the engineering properties of concrete containing granulated blast-furnace slag. *Cement and Concrete Research, 30*(4), 599-605.

Su, N., & Wu, C.-F. (2003). Effect of magnetic field treated water on mortar and concrete containing fly ash. *Cement and concrete composites, 25*(7), 681-688.

Su, K.-Z., & Yu, H.-Q. (2005). Formation and characterization of aerobic granules in a sequencing batch reactor treating soybean-processing wastewater. *Environmental Science & Technology, 39*(8), 2818-2827.

Su, B., Cui, X., & Zhu, J. (2012). Optimal cultivation and characteristics of aerobic granules with typical domestic sewage in an alternating anaerobic/aerobic sequencing batch reactor. *Bioresource technology, 110*, 125-129.

Sun, F.-y., YANG, C.-y., LI, J.-y., & YANG, Y.-j. (2006). Influence of different substrates on the formation and characteristics of aerobic granules in sequencing batch reactors. *Journal of Environmental Sciences, 18*(5), 864-871.

Sun, X.-F., Wang, S.-G., Liu, X.-W., Gong, W.-X., Bao, N., Gao, B.-Y., & Zhang, H.-Y. (2008). Biosorption of Malachite Green from aqueous solutions onto aerobic granules: Kinetic and equilibrium studies. *Bioresource technology, 99*(9), 3475-3483.

Sun, H., Yu, P., Li, Q., Ren, H., Liu, B., Ye, L., & Zhang, X.-X. (2017). Transformation of anaerobic granules into aerobic granules and the succession of bacterial community. *Applied microbiology and biotechnology, 101*(20), 7703-7713.

Tai, C. Y., Wu, C.-K., & Chang, M.-C. (2008). Effects of magnetic field on the crystallization of CaCO3 using permanent magnets. *Chemical Engineering Science, 63*(23), 5606-5612.

Tao, J., Qin, L., Liu, X., Li, B., Chen, J., You, J., . . . Chen, X. (2017). Effect of granular activated carbon on the aerobic granulation of sludge and its mechanism. *Bioresource technology, 236*, 60-67.

Tay, J.-H., Liu, Q.-S., & Liu, Y. (2001a). The effects of shear force on the formation, structure and metabolism of aerobic granules. *Applied microbiology and biotechnology, 57*(1-2), 227-233.

Tay, J. H., Liu, Q. S., & Liu, Y. (2001b). Microscopic observation of aerobic granulation in sequential aerobic sludge blanket reactor. *Journal of applied microbiology, 91*(1), 168-175.

Tay, J. H., Ivanov, V., Pan, S., & Tay, S. L. (2002). Specific layers in aerobically grown microbial granules. *Letters in Applied Microbiology, 34*(4), 254-257.

Tay, J.-H., Pan, S., Tay, S., Ivanov, V., & Liu, Y. (2003). The effect of organic loading rate on the aerobic granulation: the development of shear force theory. *Water Science and Technology, 47*(11), 235-240.

Tay, J.-H., Pan, S., He, Y., & Tay, S. T. L. (2004). Effect of organic loading rate on aerobic granulation. II: Characteristics of aerobic granules. *Journal of environmental engineering, 130*(10), 1102-1109.

Tay, S. T.-L., Moy, B. Y.-P., Jiang, H.-L., & Tay, J.-H. (2005). Rapid cultivation of stable aerobic phenol-degrading granules using acetate-fed granules as microbial seed. *Journal of Biotechnology, 115*(4), 387-395.

Thanh, B. X., Visvanathan, C., & Aim, R. B. (2009). Characterization of aerobic granular sludge at various organic loading rates. *Process Biochemistry, 44*(2), 242-245.

Toh, S., Tay, J., Moy, B., Ivanov, V., & Tay, S. (2003). Size-effect on the physical characteristics of the aerobic granule in a SBR. *Applied microbiology and biotechnology, 60*(6), 687-695.

Tomar, S. K., & Chakraborty, S. (2018). Effect of air flow rate on development of aerobic granules, biomass activity and nitrification efficiency for treating phenol, thiocyanate and ammonium. *Journal of environmental management, 219*, 178-188.

Tomska, A., & Wolny, L. (2008). Enhancement of biological wastewater treatment by magnetic field exposure. *Desalination, 222*(1-3), 368-373.

Tsuneda, S., Nagano, T., Hoshino, T., Ejiri, Y., Noda, N., & Hirata, A. (2003). Characterization of nitrifying granules produced in an aerobic upflow fluidized bed reactor. *Water research, 37*(20), 4965-4973.

Tu, R., Jin, W., Xi, T., Yang, Q., Han, S.-F., & Abomohra, A. E.-F. (2015). Effect of static magnetic field on the oxygen production of Scenedesmus obliquus cultivated in municipal wastewater. *Water research, 86*, 132-138.

Tuutijärvi, T., Lu, J., Sillanpää, M., & Chen, G. (2010). Adsorption mechanism of arsenate on crystal γ-Fe 2 O 3 nanoparticles. *Journal of environmental engineering, 136*(9), 897-905.

Utsunomiya, T., Yamane, Y.-I., Watanabe, M., & Sasaki, K. (2003). Stimulation of porphyrin production by application of an external magnetic field to a photosynthetic bacterium, Rhodobacter sphaeroides. *Journal of bioscience and bioengineering, 95*(4), 401-404.

Van Loosdrecht, M., Eikelboom, D., Gjaltema, A., Mulder, A., Tijhuis, L., & Heijnen, J. (1995). Biofilm structures. *Water Science and Technology, 32*(8), 35-43.

Vanrolleghem, P. A., Kong, Z., Rombouts, G., & Verstraete, W. (1994). An on-line respirographic biosensor for the characterization of load and toxicity of wastewaters. *Journal of Chemical Technology & Biotechnology: International Research in Process, Environmental AND Clean Technology, 59*(4), 321-333.

Verawaty, M., Pijuan, M., Yuan, Z., & Bond, P. (2012). Determining the mechanisms for aerobic granulation from mixed seed of floccular and crushed granules in activated sludge wastewater treatment. *Water research, 46*(3), 761-771.

Vick, W. S. (1991). *Magnetic fluid conditioning.* Paper presented at the Environmental Engineering.

Wahid, Z. A., Othman, F., & Sohaili, J. (2001). Electromagnetic technology on sewage treatment. *Malaysian Journal Of Civil Engineering, 13*(1).

Wan Salida, W., & Johan, S. Effect of Magnetic Field on Phosphorus Removal in Leachate.

Wang, Z.-W., Liu, Y., & Tay, J.-H. (2005). Distribution of EPS and cell surface hydrophobicity in aerobic granules. *Applied microbiology and biotechnology, 69*(4), 469.

Wang, Z., Liu, L., Yao, J., & Cai, W. (2006). Effects of extracellular polymeric substances on aerobic granulation in sequencing batch reactors. *Chemosphere, 63*(10), 1728-1735.

Wang, S.-G., Liu, X.-W., Gong, W.-X., Gao, B.-Y., Zhang, D.-H., & Yu, H.-Q. (2007a). Aerobic granulation with brewery wastewater in a sequencing batch reactor. *Bioresource technology, 98*(11), 2142-2147.

Wang, X., Zhang, H., Yang, F., Xia, L., & Gao, M. (2007b). Improved stability and performance of aerobic granules under stepwise increased selection pressure. *Enzyme and Microbial Technology, 41*(3), 205-211.

Wang, S. G., Gai, L. H., Zhao, L. J., Fan, M. H., Gong, W. X., Gao, B. Y., & Ma, Y. (2009). Aerobic granules for low- strength wastewater treatment: formation, structure, and microbial community. *Journal of Chemical Technology & Biotechnology: International Research in Process, Environmental & Clean Technology, 84*(7), 1015-1020.

Wang, D., & Zhou, L. (2010). Cultivation of aerobic granular sludge and characterization of nitrobenzene-degrading. *Huan jing ke xue= Huanjing kexue, 31*(1), 147-152.

Wang, Z., Xue, M., Huang, K., & Liu, Z. (2011). Textile dyeing wastewater treatment. Advances in treating textile effluent, 5, 91-116.

Wang, X. H., Diao, M. H., Yang, Y., Shi, Y. J., Gao, M. M., & Wang, S. G. (2012). Enhanced aerobic nitrifying granulation by static magnetic field. *Bioresour Technol, 110*, 105-110.

Wang, S.-y., Tang, Y.-k., Li, K., Mo, Y.-y., Li, H.-f., & Gu, Z.-q. (2014). Combined performance of biochar sorption and magnetic separation processes for treatment of chromium-contained electroplating wastewater. *Bioresource technology, 174*, 67-73.

Wei, D., Xue, X., Chen, S., Zhang, Y., Yan, L., Wei, Q., & Du, B. (2012). Enhanced aerobic granulation and nitrogen removal by the addition of zeolite powder in a sequencing batch reactor. *Applied microbiology and biotechnology*, 1-9.

Wei, D., Xue, X., Chen, S., Zhang, Y., Yan, L., Wei, Q., & Du, B. (2013). Enhanced aerobic granulation and nitrogen removal by the addition of zeolite powder in a sequencing batch reactor. *Applied microbiology and biotechnology, 97*(20), 9235-9243.

Wilen, B.-M., Jin, B., & Lant, P. (2003). The influence of key chemical constituents in activated sludge on surface and flocculating properties. *Water research, 37*(9), 2127-2139.

Wingender, J., Neu, T. R., & Flemming, H.-C. (1999). What are bacterial extracellular polymeric substances? *Microbial extracellular polymeric substances* (pp. 1-19): Springer.

Winkler, M.-K., Bassin, J., Kleerebezem, R., Van der Lans, R., & Van Loosdrecht, M. (2012). Temperature and salt effects on settling velocity in granular sludge technology. *Water research, 46*(16), 5445-5451.

Winkler, M. H., Kleerebezem, R., Strous, M., Chandran, K., & Van Loosdrecht, M. (2013). Factors influencing the density of aerobic granular sludge. *Applied microbiology and biotechnology, 97*(16), 7459-7468.

Winkler, M.-K. H., Meunier, C., Henriet, O., Mahillon, J., Suárez-Ojeda, M. E., Del Moro, G., . . . Weissbrodt, D. G. (2018). An integrative review of granular sludge for the biological removal of nutrients and recalcitrant organic matter from wastewater. *Chemical Engineering Journal, 336*, 489-502.

Willmott, N., Guthrie, J., & Nelson, G. (1998). The biotechnology approach to colour removal from textile effluent. *Journal of the Society of Dyers and Colourists, 114*(2), 38-41.

Wirtz, R. A., & Dague, R. R. (1996). Enhancement of granulation and start-up in the anaerobic sequencing batch reactor. *Water Environment Research, 68*(5), 883-892.

Wu, J.-S., Liu, C.-H., Chu, K. H., & Suen, S.-Y. (2008). Removal of cationic dye methyl violet 2B from water by cation exchange membranes. *Journal of Membrane Science, 309*(1-2), 239-245.

Wu, C.-Y., Peng, Y.-Z., Wang, S.-Y., & Ma, Y. (2010). Enhanced biological phosphorus removal by granular sludge: from macro-to micro-scale. *Water research, 44*(3), 807-814.

Xu, Y., & Sun, S. (2008). Effect of stable weak magnetic field on Cr (VI) bio-removal in anaerobic SBR system. *Biodegradation, 19*(3), 455-462.

Xu, Y., Hou, M., Ruan, J., Qu, M., Sun, H., Xu, J., & Zhou, S. (2014). Effect of magnetic field on surface properties of Bacillus cereus CrA and its

Extracellular Polymeric Substances (EPS). *Journal of Adhesion Science and Technology, 28*(21), 2196-2208.

Yang, S.-F., Tay, J.-H., & Liu, Y. (2003). A novel granular sludge sequencing batch reactor for removal of organic and nitrogen from wastewater. *Journal of Biotechnology, 106*(1), 77-86.

Yang, S. F., Liu, Q. S., Tay, J. H., & Liu, Y. (2004a). Growth kinetics of aerobic granules developed in sequencing batch reactors. *Letters in Applied Microbiology, 38*(2), 106-112.

Yang, S.-F., Tay, J.-H., & Liu, Y. (2004b). Inhibition of free ammonia to the formation of aerobic granules. *Biochemical engineering journal, 17*(1), 41-48.

Yang, S.-F., Li, X., & Yu, H. (2008). Formation and characterisation of fungal and bacterial granules under different feeding alkalinity and pH conditions. *Process Biochemistry, 43*(1), 8-14.

Yavuz, H., & Celebi, S. S. (2000). Effects of magnetic field on activity of activated sludge in wastewater treatment. *Enzyme and Microbial Technology, 26*(1), 22-27.

Yu, H.-Q., Tay, J.-H., & Fang, H. H. (2001). The roles of calcium in sludge granulation during UASB reactor start-up. *Water research, 35*(4), 1052-1060.

Zaidi, N. S., Sohaili, J., Muda, K., & Sillanpää, M. (2014). Magnetic field application and its potential in water and wastewater treatment systems. *Separation & Purification Reviews, 43*(3), 206-240.

Zaidi, N. S. (2016). *APPLICATION OF MAGNETIC FIELD FOR REDUCTION OF SLUDGE BULKING IN ACTIVATED SLUDGE SYSTEM.* Universiti Teknologi Malaysia.

Zhang, L., Feng, X., Zhu, N., & Chen, J. (2007). Role of extracellular protein in the formation and stability of aerobic granules. *Enzyme and Microbial Technology, 41*(5), 551-557.

Zhang, Z., Wu, W., & Wang, J. (2010). Granulation of completely autotrophic nitrifying sludge in sequencing batch reactor. *Huan jing ke xue= Huanjing kexue, 31*(1), 140-146.

Zhang, H., Dong, F., Jiang, T., Wei, Y., Wang, T., & Yang, F. (2011). Aerobic granulation with low strength wastewater at low aeration rate in A/O/A SBR reactor. *Enzyme and Microbial Technology, 49*(2), 215-222.

Zhang, W., Liu, W., Zhang, J., Zhao, H., Zhang, Y., Quan, X., & Jin, Y. (2012). Characterisation of acute toxicity, genotoxicity and oxidative stress posed by textile effluent on zebrafish. Journal of environmental sciences, 24(11), 2019-2027.

Zhang, Q., Hu, J., & Lee, D.-J. (2016). Aerobic granular processes: current research trends. *Bioresource technology, 210*, 74-80.

Zhao, Y.-G., Shen, H.-Y., Pan, S.-D., & Hu, M.-Q. (2010). Synthesis, characterization and properties of ethylenediamine-functionalized Fe3O4 magnetic polymers for removal of Cr (VI) in wastewater. *Journal of hazardous materials, 182*(1-3), 295-302.

Zhao, L., Wang, H., Yang, H., He, Z., Zhou, Y., Zhang, L., & Pang, Z. (2011). Bacterial diversity of the combined ozonation-ASBR/SBR sludge reduction with simultaneous nitrogen and phosphorus removal process using PCR-DGGE. *Chinese J. Environ. Eng. Technol, 2,* 123-130.

Zhao, J., Li, N., Yu, R., Zhao, Z., & Nan, J. (2018). Magnetic field enhanced denitrification in nitrate and ammonia contaminated water under 3D/2D Mn2O3/g-C3N4 photocatalysis. *Chemical Engineering Journal, 349*, 530-538.

Zheng, Y.-M., Yu, H.-Q., & Sheng, G.-P. (2005). Physical and chemical characteristics of granular activated sludge from a sequencing batch airlift reactor. *Process Biochemistry, 40*(2), 645-650.

Zheng, Y.-M., Yu, H.-Q., Liu, S.-J., & Liu, X.-Z. (2006). Formation and instability of aerobic granules under high organic loading conditions. *Chemosphere, 63*(10), 1791-1800.

Zhou, J.-h., Zhao, H., Hu, M., Yu, H.-t., Xu, X.-y., Vidonish, J., . . . Zhu, L. (2015). Granular activated carbon as nucleating agent for aerobic sludge granulation: Effect of GAC size on velocity field differences (GAC versus flocs) and aggregation behavior. *Bioresource technology, 198*, 358-363.

Zhu, J., & Wilderer, P. A. (2003). Effect of extended idle conditions on structure and activity of granular activated sludge. *Water research, 37*(9), 2013-2018.

Zhu, L., Xu, X., Luo, W., Cao, D., & Yang, Y. (2008). Formation and microbial community analysis of chloroanilines- degrading aerobic granules in the sequencing airlift bioreactor. *Journal of applied microbiology, 104*(1), 152-160.

Zhu, H.-Y., Fu, Y.-Q., Jiang, R., Jiang, J.-H., Xiao, L., Zeng, G.-M., . . . Wang, Y. (2011). Adsorption removal of congo red onto magnetic cellulose/Fe3O4/activated carbon composite: Equilibrium, kinetic and thermodynamic studies. *Chemical Engineering Journal, 173*(2), 494-502.

Zhu, L., Qi, H.-y., Kong, Y., Yu, Y.-w., & Xu, X.-y. (2012). Component analysis of extracellular polymeric substances (EPS) during aerobic sludge granulation using FTIR and 3D-EEM technologies. *Bioresource technology, 124*, 455-459.

Zhu, L., Zhou, J., Yu, H., & Xu, X. (2015). Optimization of hydraulic shear parameters and reactor configuration in the aerobic granular sludge process. *Environmental technology, 36*(13), 1605-1611.

Zieliński, M., Dębowski, M., Krzemieniewski, M., Dudek, M., & Grala, A. (2014). Effect of Constant Magnetic Field (CMF) with Various Values of Magnetic Induction on Effectiveness of Dairy Wastewater Treatment under Anaerobic Conditions. *Polish Journal of Environmental Studies, 23*(1).

Zieliński, M., Cydzik-Kwiatkowska, A., Zielińska, M., Dębowski, M., Rusanowska, P., & Kopańska, J. (2017). Nitrification in activated sludge exposed to static magnetic field. *Water, Air, & Soil Pollution, 228*(4), 126.

Zieliński, M., Rusanowska, P., Dębowski, M., & Hajduk, A. (2018). Influence of static magnetic field on sludge properties. *Science of The Total Environment, 625*, 738-742