HYDRODYNAMIC CAVITATION USING ORIFICE PLATE CONFIGURATIONS AND ARRANGEMENTS FOR TERTIARY TREATMENT OF PALM OIL MILL EFFLUENT

MUHAMMAD NOOR HAZWAN JUSOH

UNIVERSITI TEKNOLOGI MALAYSIA

HYDRODYNAMIC CAVITATION USING ORIFICE PLATE CONFIGURATIONS AND ARRANGEMENTS FOR TERTIARY TREATMENT OF PALM OIL MILL EFFLUENT

MUHAMMAD NOOR HAZWAN JUSOH

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

JUNE 2017

…to my lovely wife Shafiah Dolhakim
daughter Sarah Noor Liyana
parents Jusoh Jaafar and Kamariah Che Soh
thank you for your du'a, support and patience all this while…

ACKNOWLEDGEMENTS

In the name of Allah, the Almighty who gives such opportunity to further my study at this PhD level. I would like to take this opportunity to thank all the persons who have contributed in the different aspects of this study. They have all made it possible for me to commence and complete this enormous task. I would like to acknowledge and commend them for their effort, cooperation and collaboration that have worked towards the success of this study. Their positive attitude and support have taken me ahead and will also sustain the vitality of this study which serves as a contribution to both the academic and teaching/educational professional world. The work would not be possible without the contributions and involvement of the host of participants who I think will take pride in this work. All the good things happened from this journey is attributed to Allah who gives the strength and patience to me and to those persons involved to enjoy the ride in completing our trust.

To my parents, Jusoh Jaafar and Kamariah Che Soh; and mother in law, Tajiah Ahmad, thank you for your supports. The only my lovely wife, Shafiah Dolhakim thank you for being so understanding and caring for these years. My sweet little princess, Sarah Noor Liyana thank you for making wonderful and colourful life during my tough times. The whole family members deserve my wholehearted thanks as well. I am deeply grateful to my passionate supervisor, Professor Dr. Azmi Aris for patiently taking me through this difficult task of educational research. The guidance, advice, and knowledges that have shared for the past six years will not be forgotten. I would like to acknowledge the contribution of my colleagues, friends, educators, evaluators with whom I have worked during this inquiry. I wish to acknowledge Universiti Teknologi Malaysia and Ministry of Higher Education, Malaysia for supporting the study under Research University Grant Scheme (Vot No. Q J130000.2522.04H81) and MyBrain15 scholarship.

ABSTRACT

Hydrodynamic Cavitation (HC) is one of Advanced Oxidation Processes (AOPs), which generates and utilises hydroxyl radicals ($HO^{\cdot}$) as its oxidising agent. It has been studied for different applications to treat pharmaceuticals waste, seawater and microalgae, where much effort has been conducted to enhance its performance such as using pH, aeration and hydrogen peroxide (H_2O_2). However, the production of $HO^{\cdot}$ using multiple-plate combination has not yet been studied. The use of pH, aeration and H_2O_2 has proven to give significant improvement for $HO^{\cdot}$ formation, but these have not being studied previously using multiple-plate combination. The use of HC as a tertiary treatment for POME has not being reported before. Therefore, in this study, the enhancement of the HC has been investigated using double and triple orifice plate configurations and arrangements. The best system was then tested on biologically treated palm oil mill effluent (BT-POME). As the colour of POME is difficult to remove the performance of ponding treatment system was evaluated to understand the causes of colour in POME. The experiments were conducted in a lab-scale HC system, treating 10 L samples for reaction time ranging from 30 to 180 min. The effect of pH (2-7), aeration (2-10 L/min) and H_2O_2 dosing (50-200 mg/L) were explored. The performance of the HC system was based on iodine liberation, and removal of colour and chemical oxygen demand (COD). The byproducts of BT-POME degradation was identified. Additionally, the performance of an existing ponding system treating POME was assessed and the relationship between colour and few selected parameters were studied. Within the range of the experimental conditions used in this study, the HC orifice plate configurations and arrangements were found to have significant effects on $HO^{\cdot}$ generation. The iodine liberation for both double and triple plate were higher than that of a single plate. The $HO^{\cdot}$ generation was also affected by the arrangement and the distance between the plates; arrangement plate of P3P2 with 10 cm distance gave the highest iodine liberation (1296 mg/L). The performance of HC was enhanced under the effect of pH, H_2O_2 and aeration as compared to HC alone. For the conventional ponding treatment system, the anaerobic pond played the most significant role in treating POME with removal up to 97%. Among the pollutants analysed, colour has strong relationship with phenolics, tannin, lignin and carotene, indicating the roles of these compounds in causing colour of POME. The degradation of BT-POME by the HC system was not encouraging as only up to 14.7% of colour was removed, with lower removal of COD. The addition of H_2O_2 and aeration have significant effect in removing COD, while pH and addition of H_2O_2 have significant effect on colour removal. The degradation of BT-POME, particularly phenolics and tannin/lignin was found to form catechol and ρ-benzoquinone as by-products. The study showed another approach in improving HC system performance but further work is required before the system can be applied in treating BT-POME effectively.

ABSTRAK

Hydrodynamic Cavitation (HC) adalah salah satu Proses Pengoksidaan Lanjutan (AOPs) yang menghasilkan dan menggunakan radikal hidroksil ($HO^{\cdot}$) sebagai agen pengoksidaan. Ia telah dikaji untuk pelbagai kegunaan dalam merawat sisa farmaseutikal, air laut dan mikroalga, dan banyak usaha telah dijalankan untuk meningkatkan prestasinya seperti penggunaan pH, pengudaraan dan hidrogen peroksida (H_2O_2). Walau bagaimanapun, penghasilan $HO^{\cdot}$ menggunakan beberapa plat berliang belum pernah dijalankan. Penggunaan pH, pengudaraan dan H_2O_2 telah terbukti memberikan peningkatan yang bererti kepada pembentukan $HO^{\cdot}$, tetapi tidak pernah dijalankan meggunakan gabungan beberapa plat. Penggunaan HC sebagai rawatan tertier untuk POME tidak pernah dilaporkan sebelum ini. Oleh itu, dalam kajian ini, peningkatan HC telah dikaji menggunakan susunan dan konfigurasi dua dan tiga plat berliang. Sistem yang terbaik kemudiannya diuji pada air sisa kilang minyak sawit yang telah terawat secara biologi (BT-POME). Disebabkan warna POME adalah sukar untuk disingkirkan prestasi sistem kolam rawatan telah dinilai untuk memahami penyumbang kepada warna POME. Ujikaji telah dijalankan di dalam sistem HC berskala makmal, merawat 10 L sampel dengan masa tindakbalas dari 30 hingga 180 minit. Kesan pH (2-7), pengudaraan (2-10 L/min) dan dos H_2O_2 (50-200 mg/L) telah dikaji. Prestasi sistem HC adalah berdasarkan kepada penghasilan iodin, dan penyingkiran permintaan oksigen kimia (COD) serta warna. Hasil sampingan penguraian BT-POME telah dikenalpasti. Sebagai tambahan, prestasi sistem kolam rawatan POME sedia ada telah dinilai dan kaitan diantara warna dan beberapa parameter pilihan telah dikaji. Dalam julat keadaan eksperimen yang digunakan dalam kajian ini, susunan dan konfigurasi plat berliang HC didapati mempunyai kesan yang signifikan kepada penghasilan $HO^{\cdot}$. Penghasilan iodin bagi dua dan tiga plat adalah lebih tinggi berbanding plat tunggal. Penghasilan $HO^{\cdot}$ juga dipengaruhi oleh susunan dan jarak diantara plat; susunan plat P3P2 dengan jarak 10 sm menghasilkan iodin tertinggi (1296 mg/L). Prestasi HC dipertingkatkan menggunakan pH, H_2O_2 dan pengudaraan berbanding HC sahaja. Bagi sistem rawatan kolam konvensional, kolam anaerobik berperanan penting dalam merawat POME dengan penyingkiran sebanyak 97%. Dikalangan bahan pencemar yang dianalisis, warna berhubung kuat dengan fenol, tanin/lignin dan karotena, menunjukkan sebatian ini berperanan menghasilkan warna dalam POME. Penguraian BT-POME oleh sistem HC adalah tidak memberangsangkan sekadar 14.7% penyingkiran warna dengan catatan penyingkiran COD yang rendah. Penambahan H_2O_2 dan pengudaraan memberi kesan yang bererti kepada penyingkiran COD, sementara pH dan penambahan H_2O_2 memberi kesan yang bererti kepada penyingkiran warna. Penguraian BT-POME, khususnya fenol dan tanin, lignin didapati menghasilkan katekol dan ρ-benzokuinon sebagai hasil sampingan. Kajian ini menunjukkan pendekatan yang lain dalam meningkatkan prestasi sistem HC tetapi kajian lanjutan diperlukan sebelum sistem ini boleh digunakan merawat BT-POME dengan berkesan.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AOPs	-	Advanced oxidation processes
Ar	-	Argon
AC	-	Acoustic cavitation
AF	-	Anaerobic filter
AHR	-	Anaerobic hybrid reactor
ABF	-	Anaerobic baffled filter
ADF	-	Anaerobic downflow filter
ABSR	-	Anaerobic bench scale reactor
ADMI	-	American Dye Manufacturing Index
AN	-	Ammoniacal nitrogen
AC	-	Activated carbon
BOD	-	Biological oxygen demand
BT-POME	-	Biological treated palm oil mill effluent
COD	-	Chemical oxygen demand
FBR	-	Fluidised bed reactor
HC	-	Hydrodynamic cavitation
H_2O_2	-	Hydrogen peroxide
HRT	-	Hydraulic retention time
HCl	-	Hydrochloric acid
KI	-	Potassium iodide
MLSS	-	Mixed liquor suspended solids
MWCO	-	Molecular weight cut-off
MBR	-	Membrane bioreactor
MTBE	-	Methyl-tert-butyl ether
O&G	-	Oil & grease
OLR	-	Organic loading rate

POME	-	Palm oil mill effluent
P1	-	Plate 1
P2	-	Plate 2
P3	-	Plate 3
P4	-	Plate 4
P5	-	Plate 5
P6	-	Plate 6
RO4	-	Reactive orange 4
RBC	-	Rotating biological contactor
RR2	-	Reactive Red 2
TOC	-	Total organic carbon
TSS	-	Total suspended solids
TP	-	Total phosphorus
TN	-	Total nitrogen
UASB	-	Up-flow anaerobic sludge blanket
UF	-	Ultrafiltration
US	-	Ultrasound
VSS	-	Volatile suspended solids

LIST OF SYMBOLS

A	-	Total weight of flask
B	-	Tare weight of flask
Cv	-	Cavitation number
d_h	-	Diameter of the orifice
g	-	Gravity acceleration
H	-	Pressure head
H	-	Hydrogen atoms
$HO^{\cdot}$	-	Hydroxyl radical
I_3^-	-	Iodine molecules
Na_2SO_4	-	Sodium sulphate
N_2	-	Nitrogen
NaOH	-	Sodium hydroxide
n	-	Number of holes of orifice plate
O_2	-	Oxygen
P_2	-	Downstream pressure of liquid
P_v	-	Vapour pressure of liquid
Q	-	Flow rate in the main line
$R^{\cdot}$	-	Alkyl radical
RH	-	Organic substrate
ROH	-	Hydroxylated adduct-radical
$ROO^{\cdot}$	-	Peroxyl radical
ROOH	-	Hydroperoxides
t	-	Time of operation
v	-	Velocity of liquid
v_o	-	Velocity at the orifice
v_p	-	Fluid velocity of inlet pipe

α	-	Total perimeter of orifices/total area of orifices
β	-	Total area of orifices/cross sectional area of pipe
ρ	-	Density of the liquid

CHAPTER 1

INTRODUCTION

1.1 Preamble

Advanced oxidation processes (AOPs) are treatment technologies that use free radicals, particularly hydroxyl radicals ($HO^{\cdot}$) as a medium to attack and degrade organic substances. The $HO^{\cdot}$ can be formed in AOPs under photochemical and non-photochemical procedures (Quiroz *et al.,* 2011). The photochemicals consist of photo-fenton, heterogeneous photocatalysis, UV/H_2O_2 and UV/O_3. The non-photochemicals consist of alkaline media ozonation, O_3/H_2O_2, fenton and fenton-like reactions, electrochemical oxidation, cavitation and sub/super critical water.

AOPs offer several advantages against other processes such as easy operation, high efficiency, less production of residuals and toxic intermediates in the wastewater treatment (Jawale *et al.,* 2014). The formation of $HO^{\cdot}$ and other free radicals such as $H^{\cdot}$, $HO_2^{\cdot}$ and H_2O_2 contain powerful oxidizing potential which is able to degrade target contaminants in aqueous solutions (Zhang *et al.,* 2014). However, among free radicals released, only hydroxyl radical ($HO^{\cdot}$) is of particular interest because of their high oxidation capability. Its oxidizing capacity is up to 10^9 $M^{-1}\cdot s^{-1}$ stronger than ozone with second order reaction rate constant in the range of $10^6 – 10^9$ $M^{-1}\cdot s^{-1}$ (Aris, 2008).

The formation of $HO^{\cdot}$ oxidise target pollutant molecules and decompose them non-selectively to less harmful substances, leading to the ultimate mineralization products of carbon dioxide (CO_2) and water (H_2O) (Cheng *et al.,* 2016). In these process, the $HO^{\cdot}$ involves three possible mechanisms for pollutant decomposition in contaminated water which are electron transfer, radical addition and hydrogen abstraction (Mehrjouei *et al.*, 2015).

One of techniques that can be utilised to generate $HO^{\cdot}$ is cavitation. The collapse of microbubbles or cavities in cavitation can be violent enough to produce radicals. Cavitation consists of four techniques, namely acoustic, hydrodynamic, optic and particle cavitation (Gogate, 2010). Compared to other cavitation techniques, hydrodynamic cavitation (HC) is a better alternative technique to generate $HO^{\cdot}$ (Parsa *et al.*, 2013). In recent years, HC has gained considerable importance as it is a relatively benign technique with respect to economic and environmental considerations. The use of HC is preferred to generate $HO^{\cdot}$ because of less energy consumption (Arrojo and Benito, 2008; Arrojo *et al.*, 2007; Ambulgekar *et al.*, 2004; Gogate, 2002; Kumar *et al.*, 2000), simpler reaction device (Gogate and Kabadi, 2009; Ambulgekar *et al.*, 2004; Gogate, 2002), lower maintenance cost and more convenient operation (Zhang *et al.*, 2014).

The HC process involves the formation, growth and subsequent collapse of cavities that occur at small intervals of time and emit large amount of energy at several locations in a very small reactor. The $HO^{\cdot}$ is produced from the cavitation activities as it is induced by the passage of liquid through simple mechanical constrictions (orifice plate) under controlled conditions (Jadhav *et al.*, 2013). At the vena-contracta of the constriction, the pressure of the liquid is reduced lower than the vapour pressure of the liquid as it passes through the mechanical constriction at the operating temperature, hence producing a large amount of cavities. During system operation, the reduced pressure is recovered by the flow of liquid ending up at the downstream section of the constriction resulting in the subsequent collapse of the generation of cavities and the release of millions of radicals (Moholkar *et al.*, 1999).

Hydrodynamic cavitation has offered considerable promise in wastewater treatment applications due to its ability to generate $HO^{\cdot}$ in situ and the ease of operation. The successful degradation of organic pollutants using HC involved two main mechanisms which are the reaction of $HO^{\cdot}$ with the pollutants and thermal decomposition of the volatile pollutant molecule entrapped inside the cavity (Jawale *et al.,* 2014). Wang *et al.* (2009) have studied on rhodamine B degradation using swirling jet-induced cavitation combined with H_2O_2. Zhang *et al.* (2009) have investigated the degradation of C.I. Acid Orange 7 using ultrasound enhanced heterogeneous Fenton-like process. Both techniques are acceptable with the performance of rhodamine B degradation is up to 99.2% removal, while 56% of COD removal and 90% of colour removal have been removed from C.I. Acid Orange 7.

The application of HC throughout the past few decades had never been reported on the treatment of biological treated palm oil mill effluent (BT-POME). The tertiary treatment of BT-POME, however, was reported in other techniques including ultrafiltration (UF) membrane (Idris *et al.*, 2010), UV-responsive ZnO photocatalyst (Ng and Cheng, 2016) and fenton's oxidation (Aris *et al.,* 2008). The degradation of BT-POME is approximately in the ranged of 64% - 82.4% of COD removal and the colour removal is increased as high as 92.4% when using fenton's oxidation. The performance of AOPs and other techniques responded to the pollutants of BT-POME, HC method therefore could be adopted as an alternative approach for tertiary treatment of BT-POME considering of its achievement in degrading pollutants in other wastewaters.

1.2 Problem Statement

The generation of $HO^{\cdot}$ using cavitation technique has been conducted using HC reactor. The most preferred cavitation technique is the use of the orifice plate as constriction device, which operate individually in circulation closed loop reactor (Balasundaram and Harrison, 2006; Ambulgekar *et al.,* 2004; Sivakumar and Pandit, 2002; Vichare *et al.,* 2000). Several studies have been conducted to improve the capacity of HC in generating the radicals. Wang *et al.* (2015) and Ghayal *et al.* (2013) have studied the performance of multiple orifice in a single plate to generate the radicals. Additional constriction of venturi within multi-hole orifice plates have been to extend the degradation of Rhodamine B has been reported by Mishra and Gogate (2010), while Chakinala *et al.* (2008) have used chloroalkanes as additives in improving the performance of HC. Similarly, Ambulgekar *et al.* (2004) and Wu *et al.* (2015) studied the effect of aqueous potassium permanganate and hydrogen peroxide, respectively in enhancing the efficacy of cavitation.

To date, study on the HO˙ production using multiple-plate combination considering the number and arrangement of plates has not yet been published. The use of multiple-plate using HC operational mode is expected to enhance the production of huge amounts of cavities as well as the possibility of collapsing cavities enabling the formation of more HO˙. In addition, although pH, aeration and hydrogen peroxide has proven to generate more HO˙ in cavitation process (Li *et al.*, 2015; Gogate and Katekhaye, 2012; Gore *et al.*, 2014) it has never been studied on multiple-plate combination. The formation of radicals is expected to sufficiently degrade organic pollutants in wastewater treatment.

The most common and conventional method to treat POME is ponding system. Its performance in treating POME was previously evaluated; however, the performance characteristics in relation to colour of the POME has never been reported.

Colour removal for POME treatment is still an unsolved problem. While the use of techniques such as membrane separation and carbon adsorption has been reported, their applications are still remote due to unattractive cost. HC could provide another alternative in dealing with the problem. Therefore, this study focuses on the production of HO˙ using HC reactor with the novel multiple-plate combinations that are anticipated to accelerate the formation of HO˙. This technique is then tested for further removal of COD and colour of BT-POME.

1.3 Objectives of the Study

The aim of this study is to generate $HO^{\cdot}$ using HC reactor with multiple-plate combinations under appropriate conditions. The formation of $HO^{\cdot}$ observed in potassium iodide solution (KI solution) is compare their performance with BT-POME. Special attention is directed to the selected conditions for the formation of $HO^{\cdot}$ based on iodine liberation in KI solution and the best conditions for the degradation of BT-POME especially on COD and colour removal are selected.

The detail objectives of this study are as follows:

i. To evaluate the effect of HC plate configurations and arrangements in terms of orifice characteristics and number of plate on the generation of the $HO^{\cdot}$.

ii. To determine the effect of pH, H_2O_2 dosing and aeration on the performance of HC.

iii. To investigate the performance of the existing POME's pond treatment system and to relate the performance characteristics in determining the colour causing compounds.

iv. To assess the performance of the HC process in treating BT-POME with respect to COD and colour removal, colour causing compounds, and by-products formation and degradation.

1.4 Scope of the Study

This study involves the design, fabrication and application of a 10-litre laboratory-scale of HC reactor. The design and operation of the reactor were based on the system developed by Vichare *et al.* (2000). In order to enhance the formation of $HO^{\cdot}$, the cavitation chamber was modified to suit multiple-plate combinations.

The experimental works were conducted separately for observing the generation of $HO^{\cdot}$ and treatment of BT-POME. The performance in generating $HO^{\cdot}$ was observed initially in KI solution and later implemented on BT-POME. The BT-POME sample was obtained from the discharge point of the treatment ponds at Felda Bukit Besar palm oil mill. The POME in previously analysed on its characteristics from six sources of raw POME and treatment ponds. The optimised HC was later tested for treating BT-POME. Six plates with different configurations were used in this study. The plates were arranged in sequence for single-, double- and triple-plate with the distance between plates were 10cm and 20 cm. The effects of pH, hydrogen peroxide (H_2O_2) and aeration in accelerating the formation of $HO^{\cdot}$ was also investigated. The statistical approach using Excel (Microsoft), Minitab v17 (Minitab) and SPSS (IBM) for an in-depth study of the parameters involved.

1.5 Significance of the Study

The application of HC to generate $HO^{\cdot}$ employing orifice plate have been extensively reported (Braeutigam *et al.,* 2010; Balasundaram and Harrison, 2006; Kanthale *et al.,* 2005; Gogate and Pandit, 2000; Moholkar and Pandit, 1997). In addition, HC has been studied extensively for the improvement in terms of the generation of $HO^{\cdot}$ (Gogate and Patil, 2014; Gore *et al.,* 2014; Wu *et al.,* 2012; Franke *et al.,* 2011; Pradhan and Gogate, 2010; Chakinala *et al.,* 2009; Jyoti and Pandit, 2003). However, the use of multiple-plate combinations appears to be missing in the experimental study. The significance of this study are, therefore, listed as follows;

i. This study provides design and technical procedural inputs of a lab-scale HC system which was not covered in the literature. It was modified specifically for the multiple-plate combinations and to explore some other aspects of HC.

ii. The study verified the advantages of multiple-plate combinations as compared to single plate to enhance the formation of $HO^{\cdot}$. The generation of $HO^{\cdot}$ was determined based on iodine liberation.

iii. The present study provides a better understanding of the factors that affect colour of the POME. It provides a statistical relationship describing how the colour is related with other factors.

iv. This study determines the viability of HC as tertiary treatment of BT-POME under the current conditions involved. In order to verify the performance of $HO^{\cdot}$ generated, the reduction of COD and colour were quantified during the operation under similar conditions.

REFERENCES

Angaji, M.T., and Ghiaee, R. (2015). Decontamination of unsymmetrical dimethylhydrazine waste water by hydrodynamic cavitation-induced advanced Fenton process. *Ultrasonics Sonochemistry*. 23, 257 – 265.

Abid, M., Jabbar, S., Wu, T., Hashim, M.M., Hu, B., Lei, S., and Zeng, X. (2014). Sonication enhances polyphenolic compounds, sugars, carotenoids and mineral elements of apple juice. *Ultrasonics Sonochemistry*. 21, 93 – 97.

Al-Qodah, Z., Al-Bsoul, A., Assirey, E., and Al-Shanag, M. (2014). Combined ultrasonic irradaiation and aerobic biodegradation treatment for olive mills wastewaters. *Environmental Engineering and Management Journal*. 13, 8, 2109 – 2118.

Abbasi, M., Sebzari, M.R., Abadi, S.R.H., Mohammadi, T., and Mahmood. (2013). Integrated membrane pilot plant for refinery wastewater treatment in order to produce boiler feedwater. *Desalination and Water Treatment*. 51, 2543 – 2553.

Abdollahi, Y., Abdullah, A.H., Gaya, U.I., Ahmadzadeh, S., Zakaria, A., Shameli, K., Zainal, Z., Jahangirian, H., and Yusof, N.A. (2012). Photocatalytic Degradation of 1,4-Benzoquinone in Aqueous ZnO Dispersions. *J Braz Chem Soc*. 23, 2, 236 – 240.

Azaizeh, H., Halahlih, F., Najami, N., Brunner, D., Faulstich, M., and Tafesh, A. (2012). Antioxidant activity of phenolic fractions in olive mill wastewater. *Food Chemistry*. 134, 2226 – 2234.

Abdullah, N., Ujang, Z., and Yahya, A. (2011). Aerobic granular sludge formation for high strength agro-based wastewater treatment. *Bioresource Technology*, 102, 6778 – 6781.

Ashokkumar, M. (2011). The characterization of acoustic cavitation bubbles – An overview. *Ultrasonics Sonochemistry*, 18, 864 – 872.

Amin, L.P., Gogate, P.R., Burgess, A.E., and Bremner, D.H. (2010). Optimization of a hydrodynamic cavitation reactor using salicylic acid dosimetry. *Chemical Engineering Journal*. 156, 165 – 169.

Adekunte, A.O., Tiwari, B.K., Cullen, P.J., Scannell, A.G.M., and O'Donnell, C.P. (2010). Effect of sonication on colour, ascorbic acid and yeast inactivation in tomato juice. *Food Chemistry*. 122, 500 – 507.

Ahmad, A.L., Chan, C.Y., Abd Shukor, S.R., and Mashitah, M.D. (2009). Separation of oil and carotenes from palm oil mill effluent by adsorption chromatography with silica based adsorbent. *Asia-Pacific Journal of Chemical Engineering*. 4, 717 – 722.

Ahmad, A.L., Chan, C.Y., Abd Shukor, S.R., and Mashitah, M.D. (2008). Recovery of oil and carotenes from palm oil mill effluent (POME). *Chemical Engineering Journal*. 141, 383 – 386.

Aris, A., Siew, O.B., Kee, K.S., and Ujang, Z. (2008). Tertiary treatment of palm oil mill effluent using fenton oxidation. *Malaysian Journal of Civil Engineering*, 20, 1, 12 – 25.

Arrojo, S., and Benito, Y. (2008). A theoretical study of hydrodynamic cavitation. *Ultrasonics Sonochemistry*, 15, 203 – 211.

Arrojo, S., Nerin, C., and Benito, Y. (2007). Application of salicylic acid dosimetry to evaluate hydrodynamic cavitation as an advanced oxidation process. *Ultrasonics Sonochemistry*, 14, 343 – 349.

Alehossein, H., and Qin, Z. (2007). Numerical analysis of Rayleigh-Plesset equation for cavitating water jets. *Internal Journal for Numerical Method in Engineering*. 72, 780 – 807.

Avnimelech, Y. (2007). Feeding with microbial flocs by tilapia in minimal discharge bio-flocs technology ponds. *Aquaculture*. 264, 140 – 147.

Ahmad, A.L., Sumathi, S., and Hameed, B.H. (2006). Coagulation of residue oil and suspended solid in palm oil mill effluent by chitosan, alum and PAC. *Chemical Engineering Journal*. 118, 99 – 105.

Ahmad, A.L., Chong, M.F., Bhatia, S., and Ismail, S. (2006). Drinking water reclamation from palm oil mill effluent (POME) using membrane technology. *Desalination*. 191, 35 – 44.

Ahmad, A.L., Ismail, S., and Bhatia, S. (2005). Membrane treatment for palm oil mill effluent: effect of transmembrane pressure and crossflow velocity. *Desalination*. 179, 245 – 255.

Ahmad, A. L., Ismail, S., and Bhatia, S. (2005). Ultrafiltration behavior in the treatment of agro-industry effluent: Pilot scale studies. *Chemical Engineering Science*. 60, 5385 – 5394.

Aleboyeh, A., Moussa, Y., and Aleboyeh, H. (2005). The effect of operational parameters on UV/H_2O_2 decolourisation of Acid Blue 74. *Dyes and Pigments*. 66, 129 – 134.

Aleboyeh, A., Moussa, Y., and Aleboyeh, H. (2005). Kinetics of oxidative decolourisation of Acid Orange 7 in water by ultraviolet radiation in the presence of hydrogen peroxide. *Separation and Purification Technology*. 43, 143 – 148.

Ambulgekar, G.V., Samant, S.D., and Pandit, A.B. (2005). Oxidation of alkylarenes using aqueous potassium permanganate under cavitation: comparison of acoustic and hydrodynamic techniques. *Ultrasonics Sonochemistry*. 12, 85 – 90.

APHA, (2005). *Standard Methods for the Examination of Water and Wastewater*. American Public Health Association. Washington, D.C.

Ambulgekar, G.V., Samant, S.D., and Pandit, A.B. (2004). Oxidation of alkylarenes to the corresponding acids using aqueous poatssium permanganate by hydrodynamic cavitation. *Ultrasonics Sonochemistry*, 11, 191 – 196.

Adhoum, N., and Monser, L. (2004). Decolouyrization and removal of phenolic compounds from olive mill wasteawter by electrocoagulation. *Chemical Engineering and Processing*. 43, 1281 – 1287.

Aris, A. (2004). *Fenton's Reaction System For The Treatment of Textile Dyeing Wastewater*. Doctor of Philosphy. University of Manchester Institute of Science and Technology.

Ahmad, A. L., Ismail, S., and Bhatia, S. (2003). Water recycling from palm oil mill effluent (POME) using membrane technology. *Desalination*. 157, 87-95.

Arslan, İ., Balcioğlu, I.A., and Bahnemann, D.W. (2000). Advanced chemical oxidation of reactive dyes in simulated dyehouse effluents by ferrioxalate-Fenton/UV-A and TiO_2/UV-A processes. *Dyes and Pigments*. 47, 207 – 218.

Andreozzi, R., Caprio, V., Insola, A., and Marotta., R. (1999). Advanced ocidation processes (AOP) for water purification and recovery. *Catalysis Today*, 53, 51 – 59.

Barik, A.J., and Gogate, P.R. (2016). Degradation of 4-chloro 2-aminophenol using a novel combined process based on hydrodynamic cavitation, UV photolysis and ozone. *Ultrasonics Sonochemistry*. 30, 70 – 78.

Barik, A.J., and Gogate, P.R. (2016). Degradation of 4-chloro 2-aminophenol using combined strategies based on ultrasound, photolysis and ozone. *Ultrasounds Sonochemistry*. 28, 90 – 99.

Bokhari, A., Chuah, L.F., Yusup, S., Klemeš, J.J., and Kamil, R.N.M. (2016). Optmisation on pretreatment of rubber seed (*Hevea brasiliensis*) oil via wsterification reaction in a hydrodynamic cavitation reactor. *Bioresource Technology*. 199, 414 – 422.

Badve, M.P., Alpar, T., Pandit, A.B., Gogate, P.R., and Csoka, L. (2015). Modeling the shear rate and pressure drop in a hydrodynamic cavitation reactor with experimental validation based on KI decomposition studies. *Ultrasonics Sonochemistry*. 22, 272 – 277.

Badve, M.P., Bhagat, M.N., and Pandit, A.B. (2015). Microbial disinfection of seawater using hydrodynamic cavitation. *Separation and Purification Technology*. 151, 31 – 38.

Bis, M., Montusiewicz, A., Ozonek, J., and Pasieczna-Patkowska, S. (2015). Application of hydrodynamic cavitation to improve the biodegradability of mature landfill leachate. *Ultrasonics Sonochemistry*. 26, 378 – 387.

Bagal, M.V., and Gogate, P.R. (2014). Wastewater treatment using hybrid treatment schemes based on cavitation and Fenton chemistry: A review. *Ultrasonics Sonochemistry*. 21, 1 – 14.

Bagal, M.V., and Gogate, P.R. (2014). Degradation of diclofenac sodium using combined processes based on hydrodynamic cavitation and heterogeneous photocatalysis. *Ultrasonics Sonochemistry*. 21, 1035 – 1043.

Bagal, M.V., and Gogate, P.R. (2013). Degradation of 2,4-dinitrophenol using a combination of hydrodynamic cavitation, chemical and advanced oxidation processes. *Ultrasonics Sonochemistry*. 20, 1226 – 1235.

Badve, M., Gogate, P., Pandit, A., and Csoka, L. (2013). Hydrodynamic cavitation as a novel approach for wastewater treatment in wood finishing industry. *Separation and Purification Technology*. 106, 15 – 21.

Bello, M.M., Nourouzi, M.M., Abdullah, L.C., Choong, T.S.Y., Koay, Y.S., and Keshani, S. (2013). Pome is treated for removal of color from biologically treated POME in fixed bed column: Applying wavelet neural network (WNN). *Journal of Hazardous Materials*. 262, 106 – 113.

Bashir, T.A., Soni, A.G., Mahulkar, A.V., and Pandit, A.B. (2011). The CFD driven optimisation of a modified venturi for cavitational activity. *The Canadian Journal of Chemical Engineering*. 89, 1366 - 1375.

Biswas, A.K., Sahoo, J., and Chatli, M.K. (2011). A simple UV-Vis spectrophotometeric method for determination of β-carotene content in raw carrot, sweet potato and supplemented chicken meat nuggets. *LWT - Food Science and Technology*. 44, 1809 - 1813.

Burin, V.M., Falcão, L.D., Gonzaga, L.V., Fett, R., Rosier, J.P., and Bordignon-Luiz, M.T. (2010). Colour, phenolic content and antioxidant activity of grape juice. *Ciênc Technol Aliment*. 30, 4, 1027 - 1032.

Braeutigam, P., Franke, M., Wu, Z.L., and Ondruschla, B. (2010). Role of Different Parameters in the Optimization of Hydrodynamic Cavitation. *Chemical Engineering and Technology*, 33, 932 - 940.

Braeutigam, P., Wu, Z.L., Stark, A., and Ondruschka, B. (2010). Roles of Pumps and Bypass in Chemistry Induced by Hydrodynamic Cavitation. *Chemical Engineering and Technology*, 33, 2, 341 - 346.

Bilotta, G.S., and Brazier, R.E. (2008). Understanding the influence of suspended solids on water quality and aquatic biota. *Water Research*. 42, 2849 - 2861.

Bukhari, A.A. (2008). Investigation of the electro-coagulation treatment process for the removal of total suspended solids and turbidity from municipal wastewater. *Bioresource Technology*. 99, 914 - 921.

Bhatia, S., Othman, Z., and Ahmad, A.L. (2007). Pretreatment of palm oil mill effluent (POME) using *Moringa oleifera* seeds as natural coagulant. *Journal of Hazardous Materials*. 145, 120 - 126.

Barati, A.H., Mokhtari-Dizaji, M., Mozdarani, H., Bathaei, S.Z., and Hassan, Z.M. (2006). Free hydroxyl radical dosimetry by using 1 MHz low level ultrasound waves. *Iran. J. Radiat. Res.* 3, 4, 163 - 169.

Balasundaram, B., and Harrison, S.T.L. (2006). Study of Physical and Biological Factros Involved in the Disruption of *E. coli* by Hydrodynamic Cavitation. *Biotechnol. Prog.*, 22, 3, 907 - 913.

Balasundaram, B., and Harrison, S.T.L. (2006). Disruption of Brewer's Yeast by Hydrodynamic Cavitation: Process Variables and Their Influence on Selective Release. *Biotechnology and Bioengineering*, 94, 2, 303 - 311.

Bhumibhamon, O., Koprasertsak, A., Funthong. S. Kasetsart J. (2002). Biotreatment of high fat and oil wastewater by lipase producing microorganisms. *Nat. Sci*. 36, 261 – 267.

Borja, R., Banks, C.J., and Sánchez, E. (1996). Anaerobic treatment of palm oil mill effluent in a two-stage up-flow anaerobic sludge blanket (UASB) system. *Journal of Biotechnology*. 45, 125 – 135.

Borja, R., and Banks, C.J. (1995). Comparison of an anaerobic filter and an anaerobic fluidized-bed reactor treating palm oil mill effluent. *Process Biochemistry*. 30, 511 - 521.

Borja, R., and Banks, C. J. (1994a). Kinetics of methane production from palm oil mill effluent in an immobilised cell bioreactor using saponite as support medium. *Bioresource Technology*. 48, 209 - 214.

Borja, R., and Banks, C.J. (1994b). Treatment of palm oil mill effluent by upflow anaerobic filtration. *Journal of Chemical Technology and Biotechnology*. 61, 103 - 109.

Borja, R., and Banks, C.J. (1993). Thermophilic semi-continuous anaerobic treatment of palm oil mill effluent. *Biotechnology Letters*. 15, 7, 761 – 766.

Bowen, W.R., and Gan, Q. (1991). Properties of microfiltration membranes: Flux loss during constant pressure permeation of bovine serum albumin. *Biotechnology and Bioengineering*. 38, 688 - 696.

Byung, H.K., and Zeikus, J.G. (1985). Importance of hydrogen metabolism in regulation of solventogenesis by Clostridium acetobutylicum continuous culture system of hydrogen producing anaerobic bacteria. *In: Proceedings of the Eighth International Conference on Anaerobic Digestion*. 2, 383 – 390.

Cai, M., Su, J., Lian, G., Wei, X., Dong, C., Zhang, H., Jin, M., and Wei, Z. (2016). Sono-advanced Fenton decolorization of azo dye Orange G: Analysis of synergistic effect and mechanisms. *Ultrasonics Sonochemistry*. 31, 193 - 200.

Cheng, M., Zeng, G., Huang, D., Lai, C., Xu, P., Zhang, C., and Liu, Y. (2016). Hydroxyl radicals based advanced oxidation processes (AOPs) for remediation of soils contaminated with organic compounds: A review. *Chemical Engineering Journal*. 284, 582 - 598.

Chuah, L.F., Yusup, S., Aziz, A.R.A., Bokhari, A., and Abdullah, M.Z. (2016). Cleaner production of methyl ester using waste cooking oil derived from palm olein using a hydrodynamic cavitation reactor. *Journal of Cleaner Production*. 112, 4505 - 4514.

Cioncolini, A., Scenini, F., Duff, J., Szolcek, M., and Curioni, M. (2016), Choked cavitation in micro-orifices: An experimental study. *Experimental Thermal and Fluid Science*. 74, 49 - 57.

Capocelli, M., Musmarra, D., Prisciandaro, M., and Lancia, A. (2014). Chemical Effect of hydrodynamic Cavitation: Simulation and Experimental Comparison. *American Institute of Chemical Engineers*. 60, 7, 2566 - 2572.

Capocelli, M., Prisciandaro, M., Lancia, A., and Musmarra, D. (2014). Hydrodynamic cavitation of p-nitrophenol: A theoretical and experimental insight. *Chemical Engineering Journal*. 254, 1 - 8.

Chakma, S., and Moholkar, V.S. (2013). Numerical Simulation and Investigation of System Parameters of Sonochemical Process. *Chinese Journal of Engineering*. 362682, 1 - 14.

Christhudas, I.V.S.N., Kumar, P.P., Sunil, C., Vajravijayan, S., Sundaram, R.L., Siril, S.J., and Agastian, P. (2013). *In vitro* studies on α-glucosidase inhibition, antioxidant and free radical scavenging activities of *Hedyotis biflora* L. *Food Chemistry*. 138, 1689 - 1695.

Choi, W.H., Shin, C.H., Son, S.M., Ghorpade, P.A., Kim, J.J., and Park, J.Y. (2013). Anaerobic treatment of palm oil mill effluent using combined high-rate anaerobic reactors. *Bioresource Technology*. 141, 138 - 144.

Chaiprapat, S., and Laklam, T. (2011). Enhancing digestion effeciency of POME in anaerobic sequencing batch reactor with ozonation pretreatment and cycle time reduction. *Bioresource Technology*. 102, 4061 - 4068.

Chan, Y.J., Chong, M.F., and Law, C.L. (2011). Optimization on thermophilic aerobic treatment of anaerobically digested palm oil mill effluent (POME). *Biochemical Engineering Journal*. 55, 193 - 198.

Chan, Y.J., Chong, M.F., Law, C.L., and Hassell, D.G. (2009). A review on anaerobic-aerobic treatment of industrial and municipal wastewater. *Chemical Engineering Journal*. 155, 1 - 18.

Chakinala, A.G., Gogate, P.R., Burgess, A.E., Bremner, D.H. (2009). Industrial wastewater treatment using hydrodynamic cavitation and heterogeneous advanced Fenton processing. *Chemical Engineering Journal*, 152, 498 – 502.

Chakinala, A.G., Gogate, P.R., Burgess, A.E., and Bremner, D.H. (2008). Treatment of industrial wastewater effluents using hydrodynamic cavitation and the advanced Fenton process. *Ultrasonics Sonochemistry*. 15, 49 - 54.

Chakinala, A.G., Gogate, P.R., Chand, R., Bremner, D.H., Molina, R., and Burgess, A.E. (2008). Intensification of oxidation capacity using chloroalkanes as additives in hydrodynamic cavitation reactors. *Ultrasonics Sonochemistry*. 15, 164 - 170.

Chakinala, A.G., Bremner, D.H., Gogate, P.R., Namkung, K.C., and Burgess, A.E. (2008). Multivariate analysis of phenol mineralisation by combined hydrodynamic cavitation and heterogeneous advanced Fenton processing. *Applied Catalysis B: Environmental*. 78, 11 - 18.

Chakinala, A.G., Gogate, P.R., Burgess, A.E., and Bremner, D.H. (2007). Intensification of hydroxyl radical production in sonochemical reactors. *Ultrasonics Sonochemistry*. 14, 509 - 514.

Chakinala, A.G., Bremner, D.H., Burgess, A.E., and Namkung, K.C. (2007). A modified advanced Fenton process for industrial wastewater treatment. 55, 12, 59 - 65.

Campo, J.A.D., Garcia-Gonzalez, M., and Guerrero, M. (2007). Outdoor cultivation of microalgae for carotenoid production: current state and perspectives. *Applied Microbiology and Biotechnology*. 74, 1163-1174.

Cammarota, M.C., and Freire, D.M.G. (2006). A review on hydrolytic enzymes in the treatment of wastewater with high oil and grease content. *Bioresource Technology*. 97, 2195 - 2210.

Correll, D.L., Jordan, T.E., and Weller, D.E. (2000). Beaver pond biogeochemical effects in the Maryland Coastal Plain. *Biogeochemistry*. 49, 217 - 239.

Chin, K.K., Lee, S.W., Mohammad, H.H. (1996). A study of palm oil mill effluent treatment using a pond system. *Water Science and Technology*. 34, 119 - 123.

Choo, Y.M., Yap, S.C., Ooi, C.K., Ma, A.N., Goh, S.H. and Ong, A. (1996). Recovered oil from palm-pressed fiber: A good source of natural carotenoids, vitamin E, and sterols. *Journal of the American Oil Chemists' Society*. 73, 599-602.

Cail, R.G., and Barford, J.P. (1985a). Mesophilic semi-continuous anaerobic digestion of palm oil mill effluent. *Biomass*. 7, 287 – 295.

Cail, R.G., and Barford, J.P. (1985b). Thermophilic semi-continuous anaerobic digestion of palm oil mill effluent. *Agric. Wastes*. 13, 295 – 304.

Chin, K.K., and Wong, K.K. (1983). Thermophilic anaerobic digestion of palm oil mill effluent. *Water Res*. 17, 9, 993 – 995.

Church, B.D., Erickson, E.E., and Widmer, C.M. (1973). Fungal digestion of food processing wastes. *Food technol*. 27, 36.

Dular, M., Griessler-Bulc, T., Gutierrez-Aguirre, I., Heath, E., Kosjek, T., Klemenčič, A.K., Oder, M., Petkovšek, M., Rački, N., Ravnikar, M., Šarc, A., Širok, B., Zupanc, M., Žitnik, M., and Kompare, B. (2016). Use of hydrodynamic cavitation in (waste)water treatment. *Ultrasonics Sonochemistry*. 29, 577 - 588.

Davis, A.R., Fish, W.W., and Perkins-Veazie, P. (2008). A Rapid Spectrophotometric Method to Determine β-Carotene Content in *Cucumis melo* germplasm. *Cucurbit Genetics Cooperative Report*. 31 - 32, 5 - 7.

Downing, L.S., and Nerenberg, R. (2008). Total nitrogen removal in a hybrid, membrane-aerated activated sludge process. *Water Research*. 42, 3697 - 3708.

Dizhbite, T., Telysheva, G., Jurkjane, V., and Viesturs, U. (2004). Characterization of the redical scavenging activity of ligning-natural antioxidants. *Bioresource Technology*. 95, 309 - 317.

Diez, M.C., Castillo, G., Aguilar, L., Vidal, G., and Mora, M.L. (2002). Operational factors and nutrient effects on activated sludge treatment of *Pinus radiata* kraft mill wastewater. *Bioresource Technology*. 83, 131 - 138.

Ebrahiminia, A., Mokhtari-Dizaji, M., and Toliyat, T. (2016). Dual frequency cavitation event sensor with iodide dosimeter. *Ultrasonics Sonochemistry*. 28, 276 - 282.

Ebrahiminia, A., Mokhtari-Dizaji, M., and Toliyat, T. (2013). Correlation between iodide dosimetry and terephthalic acid dosimetry to evaluate the reactive radical production due to the acoustic cavitation activity. *Ultrasonics Sonochemistry*. 20, 366 - 372.

El-Gohary, F.A., Badawy, M.I., El-Khateeb, M.A., and El-Kalliny, A.S. (2009). Integrated treatment of olive mill wastewater (OMW) by the combination of Fenton's reaction and anaerobic treatment. *Journal of Hazardous Materials*. 162, 1536 - 1541.

Ebeling, J.M., Welsh, C.F., and Rishel, K.L. (2006). Performance evaluation of an inclined belt filter using coagulation/flocculation aids for the removal of suspended solids and phosphorus from microscreen backwash effluent. *Aquacultural Engineering*. 35, 61 - 77.

Farzadkia, M., Shahamat, Y.D., Nasseri, S., Mahvi, A.H., Gholami, M., and Shahryari, A. (2014). Catalytic Ozonation of Phenolic Wastewater: Identification and Toxicity of Intermediates. *Journal of Engineering*. 520929, 1 - 10.

Forchheim, D., Hornung, U., Kempe, P., Kruse, A., and Steinbach, D. (2012). Influence of Raney Nickel on the Formation of Intermediates in the Degradation of Lignin. *International Journal of Chemical Engineering*. 589747, 1 - 8.

Franke, M., Braeutigam, P., Wu, Z.L., Ren, Y., and Ondruschka, B. (2011). Enhancement of chloroform degradation by the combination of hydrodynamic and acoustic cavitation. *Ultrasonics Sonochemistry*, 18, 888 - 894.

Facta, M., Salam, Z., Buntat, Z., and Yuniarto, A. (2010). Silent discharge ozonizer for colour removal of treated palm oil mill effluent using a simple high frequency resonant power converter. *2010 IEEE International Conference on Power and Energy (PECon2010)*. 29 November - 1 December. Kuala Lumpur, Malaysia, 39 - 44.

Gogate, P.R., and Patil, P.N. (2015). Combined treatment technology based on synergism between hydrodynamic cavitation and advanced oxidation processes. *Ultrasonics Sonochemistry*. 25, 60 - 69.

Gogate, P.R., and Patil, P.N. (2014). Combined treatment technology based on synergism between hydrodynamic cavitation and advanced oxidation processes. *Ultrasonics Sonochemistry*, 25, 60 - 69.

Gore, M.M., Saharan, V.K., Pinjari, D.V., Chavan, P.V., and Pandit, A.B. (2014). Degradation of reactive orange 4 dye using hydrodynamic cavitation based hybrid techniques. *Ultrasonics Sonochemistry*, 21, 1075 - 1082.

Gogate, P.R., Shaha, S., and Csoka, L. (2014). Intensification of cavitational activity in the sonochemical reactors using gaseous additives. *Chemical Engineering Journal*. 239, 364 - 372.

Gogate, P.R., and Bhosale, G.S. (2013). Comparison of effectiveness of acoustic and hydrodynamic cavitation in combined treatment schemes for degradation of dye wastewaters. *Chemical Engineering and Processing*. 71, 59 - 69.

Gole, V.L., Naveen, K.R., and Gogate, P.R (2013). Hydrodynamic cavitation as an efficient approach for intensification of synthesis of methyl esters from sustainable feedstock. *Chemical Engineering and Processing*. 71, 70 - 76.

Ghayal, D., Pandit, A.B., and Rathod, V.K. (2013). Optimization of biodiesel production in a hydrodynamic cavitation reactor using used frying oil. *Ultrasonics Sonochemistry*. 20, 322 - 328.

Gogate, P.R., and Katekhaye, S.N. (2012). A comparison of the degree of intensification due to the use of additives in ultrasonic horn and ultrasonic bath. *Chemical Engineering and Processing*. 61, 23 - 29.

Gogate, P.R. (2011). Hydrodynamic cavitation for food and water processing. *Food and Bioprocess Technology*, 4, 6, 996 - 1011.

Guild, F.J., Kinloch, A.J., and Taylor, A.C. (2010). Particle cavitation in rubber toughened epoxies: the role of particle size. *J Mater Sci*, 45, 3882 - 3894.

Gogate, P.R and Kabadi, A.M. (2009). A review of applications of cavitation in biochemical engineering/biotechnology. *Biochemical Engineering Journal*, 44, 60 - 72.

Gogate, P.R. (2008). Treatment of wastewater streams containing phenolic compounds using hybrid techniques based on cavitation: A review of the current status and the way forward. *Ultrasonics Sonochemistry*, 15, 1 - 5.

Gogate, P.R. (2008). Cavitational reactors for process intensification of chemical processing applications: A critical review. *Chemical Engineering and Processing*, 47, 515 - 527.

García, J., Green, B.F., Lundquist, T., Mujeriego, R., Hernández-Mariné, M., and Oswald, W.J. (2006). Long term diurnal variations in contaminat removal in high rate ponds treating urban wastewater. *Bioresource Technology*. 97, 1709 - 1715.

Gogate, P.R., Tayal, R.K., and Pandit, A.B. (2006). Cavitation: A technology on the horizon. *Current Science*. 91, 35 - 46.

Gogate, P.R., and Pandit, A.B. (2005). A review and assesment of hydrodynamic cavitation as a technology for the future. *Ultrasonics Sonochemistry*. 12, 21 - 27.

Gogate, P.R., and Pandit, A.B. (2004). A review of imperative technologies for wastewater treatment I: Oxidation technologies at ambient conditions. *Advances in Environmental Research*, 8, 501 – 551.

Gogate, P.R., and Pandit, A.B. (2004). A review of imperative technologies for wastewater treatment II: Hybrid methods. *Advaces in Environmental Research*, 8, 553 - 597.

Gogate, P.R., and Pandit, A.B. (2004). Sonophotocatalytic Reactors for Wastewater Treatment: A Critical Review. *American Institute of Chemical Engineers*, 50, 5, 1051 - 1079.

Gogate, P.R., Sivakumar, M., and Pandit, A.B. (2004). Destruction of Rhodamine B sonochemical reactor with capacity of 7.5 l. *Separation and Purification Technology*. 34, 13 - 24.

Gogate, P.R., Wilhelm, A.M., and Pandit, A.B. (2003). Some aspects of the design of sonochemical reactors. *Ultrasonics Sonochemistry*. 10, 325 - 330.

Gogate, P.R., Mujumdar, S., and Pandit, A.B. (2003). Sonochemical reactors for waste water treatment: comparison using formic acid degradation as a model reaction. *Advances in Environmental Research*. 7, 283 - 299.

Gogate, P.R. (2002). Cavitation: an auxiliary technique in wastewater treatment schemes. *Advances in Environmental Research*, 6, 335 – 358.

Gogate, P.R., Shirgaonkar, I.Z., Sivakumar, M., Senthilkumar, P., Vichare, N.P., and Pandit, A.B. (2001). Cavitation Reactors: Effeciency Assessment Using a Model Reaction. *AIChE Journal*. 47, 11, 2526 - 2538.

Gogate, P.R., and Pandit, A.B. (2000). Engineering Design Methods for Cavitation Reactors II: Hydrodynamic Cavitation. *AIChE Journal*, 46, 8, 1641 - 1649.

Glaze, W.H., and Kang, J.W. (1989). Advanced Oxidation Processes. Description of a Kinetic Model for the Oxidation of Hazardous Materials in Aqueous Media with Ozone and Hydrogen Peroxide in a Semibatch Reactor. *Ind. Eng. Res*., 28, 1573 - 1580.

Hsieh, H.E., Ferng, Y.M., Chen, M.S., and Pei, B.S. (2015). Experimental study on the CHF characteristics with different coolant injection conditions and degassing effect on a downard-facing plane. *Annuals of Nuclear Energy*. 76, 48 - 53.

Halim, R., Rupasinghe, T.W.T., Tull, D.L., and Webley, P.A. (2013). Mechanical cell disruption for lipid extraction from microalgal biomass. *Bioresource Technology*. 140, 53 - 63.

Hojjat, H., Mustapha, S., and Salleh, M.A.M. (2009). Optimization of POME Anaerobic Pond. *European Journal of Scientific Research*. 32, 455 – 459.

Hsueh, C.L., Huang, Y.H., Wang, C.C., and Chen, S. (2005). Degradation of azo dyes using low iron concentration of Fenton and Fenton-like system. *Chemosphere*. 58, 1409 - 1414.

Hassan, M.A., Yacob, S., Shirai, Y., and Hung, Y.T. (2004). Treatment of Palm Oil Wastewaters. *Handbook of industrial and Hazardous wastes treatment*. 719 - 736.

Humphries, J.M., Graham, R.D., and Mares, D.J. (2004). Application of reflectance colour measurement to the estimation of carotene and lutein content in wheat and triticale. *Journal of Cereal Science*. 40, 151 - 159.

Hibiya, K., Terada, A., Tsuneda, S., and Hirata, A. (2003). Simultaneous nitrification and denitrification by controlling vertical and hozontal microenvironement in a menbrane-aerated biofilm reactor. *Journal of Biotechnology*. 100, 23 - 32.

Habib, M.A.B., Yusoff, F.M., Phang, S.M., Ang, K. J., and Mohamed, S. (1997). Nutritional values of chironomid larvae grown in palm oil mill effluent and algal culture. *Aquaculture*. 158, 95-105.

Ho, C.C and Tan, Y.K. J. (1988). The treatment of anaerobically digested palm oil mill effluent by pressurised activated sludge. *Chem. Tech. Biotechnol*. 41, 75 - 84.

Ismail, S., Idris, I., Ng, Y.T., and Ahmad, A.L. (2014). Coagulation of Palm Oil Mill Effluent (POME) at High Temperature. *Journal of Applied Sciences*. 14, 12, 1351 - 1354.

Idris, M.A., Jami, M.S., and Muyibi, S.A. (2010). Tertiary treatment of biologically treated palm oil mill effluent (POME) using UF Membrane system: Effect of MWCO and transmembrane pressure. *International Journal of Chemical and Environmental Engineering*. 2, 108 - 112.

Iida, Y., Yasui, K., Tuziuti, T., and Sivakumar, M. (2005). Sonochemistry and its dosimetry. *Mechanical Journal*. 80, 159 - 164.

Jawale, R. H., Gogate, P.R., and Pandit, A.B. (2014). Treatment of cyanide containing wastewater using cavitation based approach. *Ultrasonics Sonochemistry*, 21, 1392 - 1399.

Jeong, J.Y., Son, S.M., Pyon, J.Y., and Park, J.Y. (2014). Performance comparison between mesophilic and thermophilic anaerobic reactors for treatment of palm oil mill effluent. *Bioresource Technology*. 165, 122 - 128.

Jadhav, S.R., Saharan, V.K., Pinjari, D.V., Saini, D.R., Sonawane, S.H., and Pandit, A.B. (2013). Intensification of degradation of imidacloprid in aqueous solutions by combination of hydrodynamic cavitation with various advanced oxidation processes (AOPs). *Journal of Environmental Chemical Engineering*, 1, 850 - 857.

Joshi, R.K., and Gogate, P.R. (2012). Degradation of dichlorvos using hydrodynamic cavitation based treatment strategies. *Ultrasonics Sonochemistry*. 19, 532 - 539.

Jyoti, K.K., and Pandit, A.B. (2004a). Effect of cavitation on chemical disinfection efficiency. *Water Research*. 38, 2249 - 2258.

Jyoti, K.K., and Pandit, A.B. (2004b). Ozone and cavitation for water disinfection. *Biochemical Engineering Journal*. 18, 9 - 19.

Jyoti, K.K., and Pandit, A.B. (2003). Hybrid cavitation methods for water disinfection: simultaneous use of chemicals with cavitation. *Ultrasonics Sonochemistry*, 10, 255 – 264.

Jyoti, K.K., and Pandit, A.B. (2003). Hybrid cavitation methods for water disinfection. *Biochemical Engineering Journal*, 14, 9 -7.

Jyoti, K.K., and Pandit, A.B. (2001). Water disinfection by acoustic and hydrodynamic cavitation. *Biochemical Engineering Journal*. 7, 201 - 212.

Kim, B.H., Kang, Z., Ramanan, R., Choi, J.E., Cho, D.H., Oh, H.M., and Kim, H.S. (2014). Nutrient Removal and Biofuel Production in High Rate Algal Pond Using Real Municipal Wastewater. *J Microbial Biotechnol*. 24, 8, 1123 - 1132.

Kamwilaisak, K., and Wright, P.C. (2012). Investigating Laccase and Titanium Dioxide for Lignin Degradation. *Energy Fuels*. 26, 2400 - 2406.

Katekhaye, S.N., and Gogate, P.R. (2011). Intensification of cavitational activity in sonochemical reactors using different additives: Efficacy assessment using a model reaction. *Chemical Engineering and Processing*. 50, 95 - 103.

Kumar, P., and Moholkar, V.S. (2011). Numerical Assessment of Hydrodynamic Cavitation Reactors Using Organic Solvents. *Industrial & Engineering Chemistry Research*. 50, 4769 - 4775.

Kubicka, D., and Horácek, J. (2011). Deactivation of HDS catalysts in deoxygenation of vegetable oils. *Applied Catalysis A: General*. 394, 9 - 17.

Kelkar, M.A., Gogate, P.R., and Pandit, A.B. (2008). Intensification of esterification of acids for synthesis of biodiesel using acoustic and hydrodynamic cavitation. *Ultrasonics Sonochemistry*. 15, 188 – 194.

Krishnan, J.S., Dwivedi, P., and Moholkar, V.S. (2006). Numerical Investigation into the Chemistry Induced by Hydrodynamic Cavitation. *Ind. Eng. Res*. 45, 1493 - 1504.

Kestioğlu, K., Yonar, T., and Azbar, N. (2005). Feasibility of physico-chemical treatment and Advanced Oxidation Processes (AOPs) as a means of pretretament of olive mill effluent (OME). *Process Biochemistry*. 40, 2409 - 2416.

Kanthale, P.M., Gogate, P.R., Pandit, A.B., and Wilhelm, A.M. (2005). Dynamics of cavitational bubbles and design of a hydrodynamic cavitational reactor: cluster approach. *Ultrasonics Sonochemistry*, 12, 441 - 452.

Khanal, S.K., Chen, W.H., Li, L., and Sung, S. (2004). Biological hydrogen production: effects of pH and intermediate products. *Int. J. Hydrogen Energy*. 29, 1123 – 1131.

Kumar, A., Kumar, S., and Kumar, S. (2003). Adsorption of resorcinol and catechol on granular activated carbon: Equilibrium and kinetics. *Carbon*. 41, 3015 - 3025.

Kanthale, P.M., Gogate, P.R., Pandit, A.B., and Wilhelm, A.M. (2003). Cavity cluster approach for quantification of cavitational intensity in sonochemical reactors. *Ultrasonics Sonochemistry*. 10, 181 - 189.

Koda, S., Kimura, T., Kondo, T., and Mitome, H. (2003). A standard method to calibrate sonochemical effeciency of an individual reaction system. *Ultrasonics Sonochemistry*. 10, 149 - 156.

Krausz, I.M. (2002). *Cavitational synthesis of nanostructured inorganic materials for enhanced heterogeneous catalysis.* Doctor of Philosphy. Worcester Polytechnic Institute.

Kalumuck, K.M., and Chahine, G.L. (2000). The Use of Cavitating Jets to Oxidize Organic Compounds in Water. *Journal of Fluids Engineering-Transactions of the ASME.* 122, 3, 465 - 470.

Kadirvelu, K., Palanival, M., Kalpana, R., and Rajeswari, S. (2000). Activated carbon from a agricultural by-product, for the treatment of dyeing industry wastewater. *Bioresource Technology*. 74, 263 - 265.

Kumar, P.S., and Pandit, A.B. (1999). Modeling Hydrodynamic Cavitation. *Chem Eng Technol*. 22, 12, 1017 - 1027.

Khalid, A.R., and Wan Mustafa, W.A. (1992). External of environmental regulation: Resource recovery and the utilisation of effluents. *The Environmentalist*. 12, 277 – 285.

Karim, M.I.A., and Kamil, A.Q.A. (1989). Biological Treatment of Palm Oil Mill Effluent using *Trichoderma viride*. *Biological Wastes*. 27, 143 - 152.

Kuenen, J.G., and Robertson, L.A. (1988). Ecology of nitrification and denitrification. In: Cole, J.A., and Ferguson, S.J. (Eds.). *The Nitrogen and Sulphur Cycles*. Cambridge University Press, Cambridge. 161 - 218.

Lee, H.S., Jae, J., Ha, J.M., and Suh, D.J. (2016). Hydro- and solvothermolysis of kraft lignin for maximizing production of monomeric aromatic chemicals. *Bioresource Technology*. 203, 142 - 149.

Liew, W.L., Kassim, M.A., Muda, K., Loh, S.K., and Affam, A.C. (2015). Conventional methods and emerging wastewater polishing technologies for palm oil mill effluent treatment: A review. *Journal of Environmental Management*, 149, 222 - 235.

Lee, I., and Han, J.I. (2015). Simultaneous treatment (cell disruption and lipid extraction) of wet microalgae using hydrodynamic cavitation for enhancing the lipid yield. *Bioresource Technology*. 186, 246 - 251.

Li, P., Song, Y., Wang, S., Tao, Z., Yu, S., and Liu, Y. (2015). Enhanced decolorization of methyl orange using zero-valent copper nanoparticles under assistance if hydrodynamic cavitation. *Ultrasonics Sonochemistry*. 22, 132 - 138.

Li, P., Song, Y., Yu, S., and Park, H.D. (2015). The effect of hydrodynamic cavitation on *Microcystis aeruginosa*: Physical and chemical factors. *Chemosphere*. 136, 245 - 251.

Li, N., Jiang, J., Chen, D., Xu, Q., Li, H., and Lu, J. (2015). A reusable immobilization matrix for the biodegradation of phenol at 5000 mg/L. *Scientific Reports*. 5, 8628, 1 - 5.

Li, P., Song, Y., and Yu, S. (2014). Removal of *Microcystis aeruginosa* using hydrodynamic cavitation: Performance and mechanisms. *Water Research*. 62, 241 - 248.

Lim, M., Son, Y., and Khim, J. (2014). The effects of hydrogen peroxide on the sonochemical degradation of phenol and bisphenol A.*Ultrasonics Sonochemistry*. 21, 1976 - 1981.

Lu, Y., Yong, L., Binwei, X., and Weiqin, Z. (2012). Phenol Oxidation by Combined Cavitation Water Jet and Hydrogen Peroxide. *Chinese Journal of Chemical Engineering*. 20, 4, 760 767.

Lam, M.K., and Lee, K.T. (2011). Renewable and sustaniable bioenergies production from palm oil mill effluent (POME): Win - win strategies toward better environmental protection. *Biotechnology Advances*. 29, 124 - 141.

Latif, M.A., Ghufran, R., Wahid, Z.A., and Ahmad, A. (2011). Integrated application of upflow anaerobic sludge blanket reactor for the treatment of wastewaters. *Water Research*. 45, 4683 - 4699.

Lau, T.K., Chu, W., and Graham, N. (2007). Reaction pathways and kinetics of butylated hydroxyanisole with UV, ozonation, and UV/O_3 processes. *Water Research*. 41, 765 - 774.

Li, Y., Shahbazi, A., and Kadzere, C.T. (2006). Separation of cells and proteins from fermentation broth using ultrafiltration. *J. Food Eng*. 75, 574 - 580.

Lee, D.S., Jeon, C.O., and Park, J.M. (2001). Biological nitrogen removal with enhanced phosphate uptake in a sequencing batch reactor using single sludge system. *Wat Res.* 35, 16, 3968 - 3976.

Lobbes, J.M., Flitznar, H.P., and Kattner, G. (1999). High-Performance Liquid Chromatography of Lignin-Derived Phenols in Environmental Samples with Diode Array Detection. *Anal Chem*. 71, 3008 - 3012.

Malaysian Palm Oil Board (MPOB) (2016). Palm Oil Update - for the Latest Information on Palm Oil. Ministry of Plantation Industries and Commodities Malaysia.

Malaysian Palm Oil Board (MPOB) (2015). Palm Oil Update - for the Latest Information on Palm Oil. Ministry of Plantation Industries and Commodities Malaysia.

Maehrjouei, M., Müller, S., and Möller, D. (2015). A review on photocatalytic ozonation used for the treatment of water and wastewater. *Chemical Engineering Journal*. 263, 209 - 219.

Malaysian Palm Oil Board (MPOB) (2014). Palm Oil Update - for the Latest Information on Palm Oil. Ministry of Plantation Industries and Commodities Malaysia.

Mohammed, R.R., and Chong, M.F. (2014). Treatment and decolourization of biologically treated Palm Oil Mill Effluent (POME) using banana peel as novel biosorbent. *Journal of Environmental Management*. 132, 237 - 249.

Manickam, S., Abidin, N.Z., Parthasarathy, S., Alzorqi, I., Ng, E.H., Tiong, T.J., Gomes, R.L., and Ali, A. (2014). Role of H_2O_2 in the fluctuating patterns of COD (chemical oxygen demand) during the treatment of palm oil mill effluent (POME) using pilot scale triple frequency ultrasound cavitation reactor. *Ultrasonics Sonochemistry*. 21, 1519 - 1526.

Mohammed, R.R., Ketabchi, M.R., and 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.

Moussavi, G., and Aghanejad, M. (2014). The performance of electrochemical peroxidation process for COD reduction and biodegradability improvement of the wastewater from a paper recycling plant. *Separation and Purification Technology*. 132, 182 - 186.

Merouani, S., Hamdaoui, O., Saoudi, F., and Chiha, M. (2010). Influence of experimental parameters on sonochemistry dosimetries: KI oxidation, Fricke reaction and H_2O_2 production. *Journal of Hazardous Materials*. 178, 1007 - 1014.

Mishra, K.P., and Gogate, P.R. (2010). Intensification of degradation Rhodamine B using hydrodynamic cavitation in the presence of additives. *Separation and Purification Technology*. 75, 385 - 391.

Morison, K.R., and Hutchinson, C.A. (2009). Limitations of the Weissler reaction as a model reaction for measuring the effeciency of hydrodynamic cavitation. *Ultrasonics Sonochemistry*. 16, 176 - 183.

Muthukumar, M., Sargunamani, D., Selvakumar, N., and Rao, J.V. (2004). Optimisation of ozone treatment for colour and COD removal of acid dye effluent using central composite design experiment. *Dye and Pigments*. 63, 127 - 134.

Metcalf and Eddy. (2004). *Wastewater Engineering: Treatment and Reuse*. (4th ed.) New York: McGraw Hill.

Meriç, S., Kaptan, D., and Ölmez, T. (2004). Color and COD removal from wastewater containing Reactive Black 5 using Fenton's oxidation process. *Chemosphere*. 54, 435 - 441.

Malik, P.K., and Saha, S.K. (2003). Oxidation of direct dyes with hydrogen peroxide using ferrous ion as catalyst. *Separation and Purification Technology*. 31, 241 - 250.

Maartens, A., Jacobs, E.P., and Swart, P. (2002). Ultrafiltration of pulp and paper effluent: membrane fouling-prevention and cleaning. *Journal of Membrane Science*. 209, 81 - 92.

Moholkar, V.S., Kumar, P.S., and Pandit, A.B. (1999). Hydrodynamic cavitation for sonochemical effects. *Ultrasonics Sonochemistry*. 6, 53 - 65.

McCall, J., Alexander, C., and Richter, M.M. (1999). Quenching of Electrogenerated Chemiluminescence by Phenols, Hydroquinones, Catechols, and Benzoquinones. *Anal Chem.* 71, 2523 - 2527.

McDonald, R.C., and Wolverton, B.C. (1980). Comparative Study of Wastewater Lagoon with and without Water Hyacinth. *Economic Botany*. 34, 2, 101 - 110.

Moholkar, V.S., and Pandit, A.B. (1997). Bubble Behaviour in Hydrodynamic Cavitation: Effect of Turbulence. *AIChe Journal,* 43, 6, 1641 - 1648.

Morch, K.A. (1982). Energy considerations on the collapse of cavity clusters. *Applied Scientific Research*. 38, 1, 313 - 321.

Ng, K.H., Lee, C.H., Khan, M.R., and Cheng, C.K. (2016). Photocatalytic degradation of recalcitrant POME waste by using silver doped titania: Photokinetics and scavenging studies. *Chemical Engineering Journal*. 286, 282 - 290.

Ng, K.H., and Cheng, C.K. (2016). Photo-polishing of POME into CH_4-lean biogas over the UV-responsive ZnO photocatalyst. *Chemical Engineering Journal*. 300, 127 - 138.

Ng, K.H., and Cheng, C.K. (2015). A novel photomineralization of POME over UV-responsive TiO_2 photocatalyst: kinetics of POME degradation and gaseous product formations. *The Royal Society of Chemistry*. 5, 53100 - 53110.

Neoh, C.H., Lam, C.Y., Lim, C.K., Yahya, A., and Ibrahim, Z. (2014). Decolourization of palm oil mill effluent using growing cultures of *Curvularia clavata*. *Environ Sci Pollut Res*. 21, 4397 - 4408.

Nazir, N.M. (2013). *Biodeolourisation of Palm Oil Mill Effluent (POME) by selected exogenous bacteria*. Masters, Universiti Teknologi Malaysia, Skudai.

Naddeo, V., Belgiorno, V., Kassinos, D., Mantzavinos, D., and Meric, S. (2010). Ultrasonic degradation, mineralization and detoxification of diclofenac in water: Optimization of operating parameters. *Ultrasonics Sonochemistry*. 17, 179 - 185.

Najafpour, G.D., Zinatizadeh, A.A.L., Mohamed, A. R., Isa, M.H., Nasrollahzadeh, H. (2006). High-rate anaerobic digestion of palm oil mill effluent in an upflow anaerobic sludge-fixed film bioreactor. *Process Biochemistry*. 41, 370 - 379.

Najafpour, G., Yieng, H.A., Younesi, H., and Zinatizadeh, A. (2005). Effect of organic loading on performance of rotating biological contactors using Palm Oil Mill effluents. *Process Biochemistry*. 40, 2879 – 2882.

Ning, P., Bart, H.J., Jiang, Y., de Haan, A., and Tien, C. (2005). Treatment of organic pollutants in coke plant wastewater by the method of ultrasonic irradiation, catalytic oxidation and activated sludge. *Separation and Purification Technology*. 41, 133 - 139.

Namasivayam, C., and Kadirvelu, K. (1994). Coirpith, and Agricultural Waste By-product, for the Treatment of Dyeing Wastewater. *Bioresource Technology*. 48, 79 - 81.

Özdemir, C., Öden, M.K., Şahinkaya, S., and Güçlü, D. (2011). The sonochemical decolorisation of textile azo dye CI Reactive Orange 127. *Coloration Technology*. 127, 268 - 273.

Okuda, K., Ohara, S., Umetsu, M., Takami, S., and Adschiri, T. (2008). Disassembly of lignin and chemical recovery in supercritical water and *p*-cresol mixture; Study on lignin model compounds. *Bioresource Technology*. 99, 1846 - 1852.

Okwute, L.O., and Isu, N.R. (2007). The environmental impact of palm oil mill effluent (pome) on some physico-chemical parameters and total aerobic bioload of soil at a dump site in Anyigba, Kogi State, Nigeria. *African Journal of Agricultural Research*. 2, 12, 656 - 662.

Oswal, N., Sarma, P.M., Zinjarde, S.S., Pant, A. (2002). Palm oil mill effluent treatment by a tropical marine yeast. *Bioresource Technology*. 85, 35 – 37.

Parthasarathy, S., Mohammed, R.R., Fong, C.M., Gomes, R.L., and Manickam, S. (2016). A novel hybrid approach of activated carbon and ultrasound cavitation for the intensification of palm oil mill effluent (pome) polishing. *Journal of Cleaner Production*. 112, 1218 - 1226.

Prajapat, A.L., and Gogate, P.R. (2015). Intensification of depolymerization of aqueous guar gum using hydrodynamic cavitation. *Chemical Engineering and Processing*. 93, 1 - 9.

Papoutsakis, S., Miralles-Cuevas, S., Gondrexon, N., Baup, S., Malato, S., and Pulgarin, C. (2015). Coupling between high-frequency altrasound and solar photo-Fenton at pilot scale for the treatment of organic contaminants: An initial approach. *Ultrasonics Sonochemistry*. 22, 527 - 534.

Perpar, M., Polutnik, E., Pečar, M., and Žun, I. (2014). Bubbly structures in a cavitating slot orifices. *Experimental Thermal and Fluid Science*. 53, 57 - 69.

Patil, P.N., Bote, S.D., and Gogate, P.R. (2014). Degradation of imidacloprid using combined advanced oxidation processes based on hydrodynamic cavitation. *Ultrasonics Sonochemistry*. 21, 1770 - 1777.

Poh, P.E., and Chong, M.F. (2014). Upflow anaerobic sludge blanket-hollow centered packed bed (UASB-HCPB) reactor for therphilic palm oil mill effluent (POME) treatment. *Biomass and Bioenergy*. 67, 231 - 242.

Parsa, J.B., and Zonouzian, S.A.E. (2013). Optimization of a heterogeneous catalytic hydrodynamic cavitation reactor performance in decolourization of Rhodamine B: Application of scrap iron sheets. *Ultrasonics Sonochemistry*, 20, 1442 - 1449.

Patil, P.N., and Gogate, P.R. (2012). Degradation of methyl parathion using hydrodynamic cavitation: Effect of operating parameters and intensification using additives. *Separation and Purification Technology*. 95, 172 - 179.

Pang, Y.L., Abdullah, A.Z., and Bhatia, S. (2011). Review on sonochemical methods in the presence of catalysts and chemical additives for treatment of organic pollutants in wastewater. *Desalination*, 277, 1 - 14.

Pendashteh, A.R., Fakhru'/-Razi, A., Chuah, T.G., Dayang Radiah, A.B., Madaeni, S.S., and Zurina, Z.A. (2010). Biological treatment of produced water in a sequencing batch reactor by a consortium of isolated halophilic microorganisms. *Environmental Technology*. 31, 11, 1229 - 1239.

Poh, P.E., Yong, W.J., and Chong, M.F. (2010). Palm Oil Mill Effluent (POME) Characteristic in High Crop Season and the Applicability of High-Rate Anaerobic Bioreactors for the Treatment of POME. *Ind. Eng. Res*. 49, 11732 - 11740.

Pradhan, A.A., and Gogate, P.R. (2010). Removal of ρ-nitrophenol using hydrodynamic cavitation and Fenton chemistry at pilot scale operation. *Chemical Engineering Journal*, 156, 77 – 82.

Pradhan, A.A., and Gogate, P.R. (2010). Degradation of p-nitrophenol using acoustic cavitation and Fenton chemistry. *Journal of Hazardous Materials*, 173, 517 - 522.

Peng, Y., and Zhu, G. (2006). Biological nitrogen removal with nitrification and denitrification vie nitrite pathway. *Appl Microbiol Biotechnol*. 73, 15 - 26.

Pala, A., and Tokat, E. (2002). Color removal from cotton textile industry wastewater in an activated sludge system with various additives. *Water Research*. 36, 2920 - 2925.

Prasertsan, S., and Prasertsan, P. (1996). Biomass Residues from Palm Oil Mills in Thailand: An Overview on Quantity and Potential Usage. *Biomass and Bioenergy*. 11, 5, 387 – 395.

Pan, B., and Hartmann, L. (1992). Activity of Biomass in RBC System Treating Pulp Indistrial Wastewater. *Journal of Environmental Engineering*. 118, 5, 744-754.

Raut-Jadhav, S., Saini, D., Sonawane, S., and Pandit, A.B. (2016). Effect of process intensifying parameters on the hydrodynamic cavitation based degradation of commercial pesticide (methomyl) in the aqueous solution. *Ultrasonics Sonochemistry*. 28, 283 - 293.

Raut-Jadhav, S., Badve, M.P., Pinjari, D.V., Saini, D.R., Sonawane, S.H., and Pandit, A.B. (2016). Treatment of the pesticide industry effluent using hydrodynamic cavitation and its combination with process intensifying additives (H_2O_2 and ozone). *Chemical Engineering Journal*. 295, 326 - 335.

Raut-Jadhav, S., Pinjari, D.V., Saini, D.R., Sonawane, S.H., and Pandit, A.B. (2016). Intensification of degradation of methomyl (carbamate group pesticide) by using the combination of ultrasonic cavitation and process intensifying additives. *Ultrasonics Sonochemistry*. 31, 135 - 142.

Rungpichayapichet, P., Mahayothee, B., Khuwijitjaru, P., Nagle, M., and Müller, J. (2015). Non-destructive determination of β-carotene content in mango by near-infrared spectroscopy compared with calorimetric measurements. *Journal of Food Composition and Analysis*. 38, 32 - 41.

Rooze, J., Rebrov, E., Schouten, J.C., and Keurentjes, J.T.F. (2013). Dissolved gas and ultrasonic cavitation - A review. *Ultrasonics Sonochemistry*. 20, 1 - 11.

Ramirez-San-Juan, J.C., Rodriguez-Aboytes, E., Martinez-Canton, A.E., Baldovino-Pantaleon, O., Robledo-Martinez, A., Korneev, N., and Ramos-Garcia, R. (2010). Time-resolved analysis of cavitation induced by CW lasers in absorbing liquids. *Optic Express*, 18, 9, 8735 - 8742.

Rupani, P.F., Singh, R.P., Ibrahim, M.H., and Esa, N. (2010). Review of Current Palm Oil Mill Effluent (POME) Treatment Methods: Vermicomposting as a Sustainable Practice. *World Applied Sciences Journal*. 10, 10, 1190 – 1201.

Ruiz, G., Jeison, D., Rubilar, O., Ciudad, G., and Chamy, R. (2006). Nitrification-denitrification via nitrite accumulation for nitrogen removal from wastewaters. *Bioresource Technology*. 97, 330 - 335.

Ramirez, J.H., Costa, C.A., and Maderia, L.M. (2005). Experimental design to optimize the degradation of synthetic dye orange II using Fenton's reagent. *Catal. Today*. 107, 68 - 76.

Rajbhandari, B.K., and Annachhatre, A.P. (2004). Anaerobic ponds treatment of starch wastewater: case study in Thailand. *Bioresource Technology*. 95, 135 - 143.

Ralph, J., Lundquist, K., Brunow, G., Lu, F., Kim, H., Schatz, P.F., Marita, J.M., Hatfield, R.D., Ralph, S.A., Christensen, J.H., and Boerjan, W. (2004). Lignins: Natural polymers from oxidative coupling of 4-hydroxyphenyl-propanoids. *Phytochemistry Reviews*. 3, 29 - 60.

Ravanello, M.P., Ke, D., Alvarez, J., Huang, B., and Shewmaker, C.K. (2003). Coordinate expression of multiple bacterial carotenoid genes in canola leading to altered carotenoid production. *Metabolic Engineering*. 5, 255-263.

Schmidt, M.A., Parrott, W.A., Hildebrand, D.F., Berg, R.H., Cooksey, A., Pendarvis, K., He, Y., McCarthy, F., and Herman, E.M. (2015). Transgenic soya bean seeds accumulating β-carotene exhibit the collateral enhancements of oleate and protein content traits. *Plant Biotechnology Journal*. 13, 590 - 600.

Saifuddin, N., Saltanat, A., and Refal, H. (2014). Enhancing the Removal of Phenolic Compounds from Palm Oil Mill Effluent by Enzymatic Pre-treatment and Microwave-Assisted Extraction. *Chemical Science Transaction*. 3, 3, 1083 - 1093.

Shin, J.W., Pyeon, J.H., Son, S.M., Jeong, J.Y., and Park, J.Y. (2014). Performance evaluation of a field-scale pilot bioreactor for anaerobic treatment of palm oil mill effluent. *International Biodeterioration & Biodegradation*. 95, 89 - 92.

Sponza, D.T., and Oztekin, R. (2014). Dephenolization, dearomatization and detoxification of olive mill wastewater with sonication combined with additives and radical scavengers. *Ultrasonics Sonochemistry*. 21, 1244 - 1257.

Şahinkaya, S. (2013). COD and color removal from synthetic textile wastewater by ultrasound assisted electro-Fenton oxidation process. *Journal of Industrial and Engineering Chemistry*. 19, 601 - 605.

Silva, M.C., Torres, J.A., de Sá, L.R.V., Chagas, P.M.B., Ferreira-Leitão, V.S., and Corrêa, A.D. (2013). The use of soybean peroxidase in the decolourisation of Remazol Brilliant Blue R and toxicological evaluation of its degradation products. *Journal of Molecular Catalysis B: Enzymatic*. 89, 122 - 129.

Singh, L., Wahid, Z.A., Siddiqui, M.F., Ahmad, A., Rahim, M.H.A., and Sakinah, M. (2013). Application of immobilized upflow anaerobic sludge blanket reactor using *Clostridium* LS2 for enhanced biohydrogen production and treatment efficiency of palm oil mill effluent. *International Journal of Hydrogen Energy*. 38, 2221 - 2229.

Saharan, V.K., Rizwani, M.A., Malani, A.A., and Pandit, A.B. (2013). Effect of geometry of hydrodynamically cavitating device on degradation of orange-G. *Ultrasonics Sonochemistry*. 20, 345 - 353.

Saharan, V.K., Pandit, A.B., Kumar, P.S.S., and Anandan, S. (2012). Hydrodynamic Cavitation as an Advanced Oxidation Technique for the Degradation of Acid Red 88 Dye. *Industrial & Engineering Chemistry Research*. 51, 4, 1981 - 1989.

Sun, L., Wan, S., Yu, Z., Wang, Y., and Wang, S. (2012). Anaerobic biological treatment of high strength cassava starch wastewater in a new type up-flow, multistage anaerobic reactor. *Bioresource Technology*. 104, 280 - 288.

Saharan, V.K., Badve, M.P., and Pandit, A.B. (2011). Degradation of Reactive Red 120 dye using hydrodynamic cavitation. *Chemical Engineering Journal*. 178, 100 - 107.

Schmid, A. (2010). MTBE degradation by hydrodynamic induced cavitation. *Water Science & Technology*. 61, 10, 2591 - 2594.

Sumathi, S., Chai, S. P., and Mohamed, A. R. (2008). Utilization of oil palm as a source of renewable energy in Malaysia. *Renewable and Sustainable Energy Reviews*. 12, 2404 - 2421.

Sauter, C., Emin, M.A., Schuchmann, H.P., and Tavman, S. (2008). Influence of hydrostatic pressure and sound amplitude on the ultrasound induced dispersion and de-agglomeration of nanoparticles. *Ultrasonics Sonochemistry*. 15, 517 - 523.

Sharma, A., Gogate, P.R., Mahulkar, A., and Pandit, A.B. (2008). Modeling of hydrodynamic cavitation reactors based on orifice plates considering hydrodynamics and chemical reactions occuring in bubble. *Chemical Engineering Journal*. 143, 201 - 209.

Sundram, K., Sambanthamurthi, R., and Tan, Y.A. (2003). Palm fruit chemistry and nutrition. *Asia Pacific J Clin Nutr*. 12, 3, 355 - 362.

Sivakumar, M., and Pandit, A.B. (2002). Wastewater treatment: a novel energy efficient hydrodynamic cavitation technique. *Ultrasonics Sonochemistry*, 9: 123 - 131.

Sivakumar, M., Tatake, P.A., Pandit, A.B. (2002). Kinetics of ρ-nitrophenol degradation: effect of reaction conditions and parameters for a multiple frequency system. *Chemical Engineering Journal*. 85, 327 – 338

Senthilkumar, P., Kumar, M. S., and Pandit, A.B. (2000). Experimental quantification of chemical effects of hydrodynamic cavitation. *Chemical Engineering Science*, 55, 1633 – 1639.

Shirgaonkar, I.Z., Lothe, R.R., and Pandit, A.B. (1998). Comments on the Mechanism of Microbial Cell Disruption in High-Pressure and High-Speed Devices. *Biotechnol. Prog.* 14, 657 - 660.

Save, S.S., Pandit, A.B., and Joshi, J.B. (1997). Use of hydrodynamic cavitation for large scale microbial cell disruption. *Trans IChemE*. 75, Part C, 41 - 49.

Suslick, K.S., Mdleleni, M.M., and Jeffrey T. (1997). Chemistry Induced by Hydrodynamic Cavitation. *Ries. J. Am. Chem. Soc*., 119, 9303 – 9304.

Surampalli, R.Y., Tyagi, R.D., Scheible, O.K., and Heidman, J.A. (1997). Nitrification, Denitrification and Phosphorus removal in sequential batch reactors. *Bioresource Technology*. 61, 151 - 157.

Smolders, G.J.F., van der Meiji, J., van Loosdrecht, M.C.M., and Heijnen, J.J. (1994). Stoichiometric Model of the Aerobic Metabolism of the Biological Phosphorus Removal Process. *Biotechnology and Bioengineering*. 44, 837 - 848.

Slinkard, K., and Singleton, V.L. (1977). Total Phenol Analysis: Automation and Comparison with Manual Methods. *American Journal of Enology and Viticulture*. 28, 49 - 55.

Taha, M.R., and Ibrahim, A.H. (2014). COD removal from anaerobically treated palm oil mill effleunt (AT-POME) via aerated heterogeneous Fenton process: Optimization study. *Journal of Water Process Engineering*. 1, 8 - 16.

Tátraaljai, D., Major, L., Földes, E., and Pukánszky, B. (2014). Study of the effect of natural antioxidants in polyethylene: Performance of β-carotene. *Polymer Degradation and Stability*. 102, 33 - 40.

Tran, K.V.B., Kimura, T., Kondo, T., and Koda, S. (2014). Quantification of frequency dependence of mechanical effects induced by ultrasound. *Ultrasonics Sonochemistry*. 21, 716 - 721.

Teng, T.T., Wong, Y.S., Ong, S.A., Norhashimah, M., Rafatullah, M. (2013). Start-up operation of anaerobic degradation process for palm oil mill effluent in anaerobic bench scale reactor (ABSR). *Procedia Environmental Sciences*. 18, 442 - 450.

Travis, M.J., Weisbrod, N., and Gross, A. (2012). Decentralized wetland-based treatment of oil-rich farm wastewater for rreuse in an arid environment. *Ecological Engineering*. 39, 81 - 89.

Tang, H.L., Xie, Y.F., and Chen, Y.C. (2012). Use of Bio-Amp, a commercial bio-additive for the treatment of grease trap wastewater containing fat, oil, and grease. *Bioresource Technology*. 124, 52 - 58.

Vijayaraghavan, K., Ahmad, D., and Aziz, M.E.A. (2007). Aerobic treatment of palm oil mill effluent. *Journal of Environmental Management*. 82, 24 – 31.

Vijayaraghavan, K., and Ahmad, D. (2006). Biohydrogen generation from palm oil mill effluent using anaerobic contact filter. *International Journal of Hydrogen Energy*. 31, 1284 – 1291.

Vidal, G., and Diez, M.C. (2005). Methanogenic toxicity and continuous anaerobic treatment of wood processing effluents. *Journal of Environmental Management*. 74, 317 - 325.

Villar, J.C., Caperos, A., and García-Ochoa, F. (2001). Oxidation of hardwood kraft-lignin to phenolic derivatives with oxygen as oxidant. *Wood Science and Technology*. 35, 245 - 255.

Vichare, N.P., Gogate, P.R., Pandit, A.B. (2000). Optimization of Hydrodynamic Cavitation Using a Model Reaction, *Chemical Engineering Technology*, 23, 8, 683 - 690.

Wang, J., Mahmood, Q., Qiu, J.P., Li, Y.S., Chang, Y.S., Chi, L.N., and Li, X.D. (2015). Zero Discharge Performance of an Industrial Pilot-Scale Plant Treating Palm Oil Mill Effluent. *BioMed Research International*. 617861, 1 - 9.

Wang, F., Jia, A., Wu, Y., Wu, C., and Chen, L. (2015). Disinfection of bore well water with chlorine dioxide/sodium hypochlorite and hydrodynamic cavitation. *Environmental Technology*. 36, 4, 479 - 486.

Wang, J., Mahmood, Q., Qiu, J.P., Li, Y.S., Chang, Y.S., and Li, X.D. (2015). Anaerobic Treatment of Palm Oil Mill Effluent in Pilot-Scale Anaerobic EGSB Reactor. *BioMed Research International*. 398028, 1 - 7.

Wang, X., Jia, J., and Wang, Y. (2015). Enhanced photocatalytic-electrolytic degradation of Reactive Brilliant Red X-3B in the presence of water jet cavitation. *Ultrasonics Sonochemistry*. 23, 93 - 99.

Wu, C.D., Zhang, Z.L., Wu, Y., Wang, L., and Chen, L.J. (2015). Effects of operating parameters and additives on degradation of phenol in water by the combination of H_2O_2 and hydrodynamic cavitation. *Desalination and Water Treatment*. 53, 462 - 468.

Wu, C.D., Zhang, J.Y., Wu, Y., and Wu, G.Z. (2014). Degradation of phenol in water by the combination of sonolysis and photocatalysis. *Desalination and Water Treatment*. 52, 1911 - 1918.

Wu, Z., Shen, H., Ondruschka, B., Zhang, Y., Wang, W., and Bremner, D.H. (2012). Removal of blue-green algae using the hybrid method of hydrodynamic cavitation and ozonation. *Journal of Hazardous Materials*, 235 - 236, 152 - 158.

Wang, X., Jia, J., and Wang, Y. (2011). Degradation of C.I. reactive Red 2 through photocatalysis coupled with water jet cavitation. *Journal of Hazardous Materials*. 185, 315 - 321.

Wang, J., Guo, Y., Liu, B., Jin, X., Liu, L., Xu, R., Kong, Y., and Wang, B. (2011). Detection and analysis of reactive oxygen species (ROS) generated by nano-sized TiO_2 powder under ultrasonic irradiation and application in sonocatalytic degradation of organic dyes. *Ultrasonics Sonochemistry*. 18, 177 - 183.

Wang, J., Wang, X., Guo, P., and Yu, J. (2011). Degradation of reactive brilliant red K-2BP in aqueous solution using swirling jet-induced cavitation combined with H_2O_2. *Ultrasonics Sonochemistry*. 18, 494 - 500.

Wang, X., Jia, J., and Wang, Y. (2010). Electrochemical degradation of reactive dye in the presence of water jet cavitation. *Ultrasonics Sonochemistry*. 17, 515 - 520.

Wang, Qi., Guan, Y.X., Yao, S.J., and Zhu, Z.Q. (2010). Microparticle formation of sodium cellulose sulfate using supercritical fluid assisted atomization introduced by hydrodynamic cavitation mixer. *Chemical Engineering Journal*. 159, 220 - 229.

Wu, T.Y., Mohammad, A.W., Jahim, J.M., and Anuar, N. (2010). Pollution control technologies for the treatment of palm oil mill effluent (POME) through end-of-pipe processes. *Journal of Environmental Management*. 91, 1467 - 1490.

Wang, X., and Zhang, Y. (2009). Degradation of alachlor in aqueous solution by using hydrodynamic cavitation. *Journal of Hazardous Materials*. 161, 202 – 207.

Wang, X., Wang, J., Guo, P., Guo, W., and Wang, C. (2009). Degradation of rhodamine B in aqueous solution by using swirling jet-induced cavitation combined with H_2O_2. *Journal of Hazardous Materials*, 169, 486 - 491.

Wu, T.Y., Mohammad, A.W., Jahim, J.M., and Anuar, N. (2009). A holistic approach to managing palm oil mill effluent (POME): Biotechnological advances in the sustainable reuse of POME. *Biotechnology Advances*. 27, 40 - 52.

Wu, T.Y., Mohammad, A.W., Jahim, J.M., and Anuar, N. (2009). Optimized reuse and bioconversion from retentate of pre-filtered palm oil mill effluent (POME) into microbial protease by *Aspergillus terreus* using response surface methodology. *J Chem Technol Biotechnol*. 84, 1390 - 1396.

Wu, Z., Ondruschka, B., Zhang, Y., Bremner, D.H., Shen, H., and Franke, M. (2009). Chemistry driven by suction. *The Royal Society of Chemistry*. 11, 1026 - 1030.

Wong, Y. S., Kadir, M., and Teng, T. T. (2009). Biological kinetics evaluation of anaerobic stabilization pond treatment of palm oil mill effluent. *Bioresource Technology*. 100, 4969 - 4975.

Wang, X., Yao, Z., Wang, J., Guo, W., and Li, G. (2008). Degradation of reactive brilliant red in aqueous solution by ultrasonic cavitation. *Ultrasonics Sonochemistry*. 15, 43 - 48.

Wang, X., Wang, J., Guo, P., Guo, W., and Li, G. (2008). Chemical effect of swirling jet-induced cavitation: Degradation of rhodamine B in aqueous solution. *Ultrasonics Sonochemistry*. 15, 357 – 363.

Wang, S., Wu, X., Wang, Y., Li, Q., and Tao, M. (2008). Removal of organic matter and ammonia nitrogen from landfill leachate by ultrasound. *Ultrasonics Sonochemistry*. 15, 933 - 937.

Wu, T.Y., Mohammad, A.W., Jahim, J.Md., and Anuar, N. (2007). Palm oil mill effluent (POME) treatment and bioresources recovery using ultrafiltration membrane: Effect of pressure on membrane fouling. *Biochemical Engineering Journal*. 35, 309 - 317.

Wu, Z.L., Ondruschka, B., and Brautigam, P. (2007). Degradation of Chlorocarbons Driven by Hydrodynamic Cavitation. *Chem. Eng. Technol*. 30, 5, 642 - 648.

Walt, E. V. D. (2002). The effect of ultraviolet light, cavitational flow and ultrasound on protozoan cyts and oocysts, bacteriophages and clostridium. *Biennial conference of the water institute of southern Africa (WISA)*. 19 – 23 May. Durban, South Africa: WISA.

Wu, T.Y., Mohammad, A.W., Anuar, N., and Abdul Rahman, R. Songklanakarin J. (2002). Potential use of nanofiltration membrane in treatment of wastewater from fish and surimi industries. *Sci. Technol*. 24, 977 - 987.

Wood, B.J., Pillai, K.R., and Rajaratnam, J.A. (1979). Palm oil mill effluent disposal on land. *Agricultural Wastes*. 1, 103-127.

Xiaodong, Z., Yong, F., Zhiyi, L., and Zongchang, Z. (2008). The Collapse Intensity of Cavities and the Concentration of Free Hydroxyl Radical Released in Cavitation Flow. *Chinese Journal of Chemical Engineering.* 16, 4, 547 - 551.

Yusof, N.S.M., Babgi, B., Alghamdi, Y., Aksu, M., Madhavan, J., and Ashokkumar, M. (2016). Physical and chemical effects of acoustic cavitation in selected ultrasonic cleaning applications. *Ultrasonics Sonochemistry,* 29, 568 - 576.

Yang, L., Zhou, W., Seshan, K., and Li. Y. (2013). Green and efficient synthesis route of catechol from guaicol. *Journal of Molecular Catalysis A: Chemical*. 368 - 369, 61 - 65.

Yang, X., Wang, X., and Wang, L. (2010). Transferring of components and energy output in industrial sewage sludge disposal by thermal pretreatment and two-phase anaerobic process. *Bioresource Technology*. 101, 2580 - 2584.

Yilmaz, G., Lemaire, R., Keller, J., and Yuan, Z. (2008). Simultaneous Nitrification, Denitrification, and Phosphorus Removal From Nutrient-Rich Industrial Wastewater Using Granular Sludge. *Biotechnology and Bioengineering*. 100, 3, 529 - 541.

Yejian, Z., Li, Y., Lina, C., Long, X., Zhijian, M., and Zhenjia, Z. (2008). Startup and operation of anaerobic EGSB reactor treating palm oil mill effluent. *Journal of Environmental Sciences*. 20, 658 – 663.

Yuniarto, A., Ujang, Z., and Noor., Z.Z. (2008). Bio Fouling reducer in submerged membrane bioreactor of palm oil mill effluent treatment. *Jurnal Teknologi UTM*. 49, 555 - 566.

Yacob, S., Shirai, Y., Hassan, M. A., Wakisaka, M., and Subash, S. (2006). Start-up operation of semi-commercial closed anaerobic digester for palm oil mill effluent treatment. *Process Biochemistry*. 41, 962-964.

Zhao, H., Zhang, P., Zhang, G., and Cheng, R. (2016). Enhancement of ultrasonic disintegration of sewage sludge by aeration. *Journal of Environmental Sciences*. 42, 163 - 167.

Zhou, H., Liu, J., Xia, H., Zhang, Q., Ying, T., and Hu, T. (2015). Removal and reduction of selected organic micro-pollutants in effluent sewage by the ozone-based oxidation processes. *Chemical Engineering Journal*, 269, 245 - 254.

Zhou, H., Shen, Y., Lv, P., Wang, J., and Li, P. (2015). Degradation pathway and kinetics of 1-alkyl-3-methylimidazolium bromides oxidation in an ultrasonic nanoscale zero-valent iron/hydrogen peroxide system. *Journal of Hazardous Materials*, 284, 241 - 252.

Zahrim, A.Y., Nasimah, A., and Hilal, N. (2014). Pollutants analysis during conventional palm oil mill effluent (POME) ponding system and decolourisation of anaerobically treated POME via calcium lactate-polyacrylamide. *Journal of Water Process Engineering*. 4, 159 - 165.

Zhang, L., Belova, V., Wang, H., Dong, W., and Möhwald, H. (2014). Controlled Cavitation at Nano/Microparticle Surfaces. *Chemistry of Materials*, 26, 2244 - 2248.

Zeb, A. (2012). Oxidation and formation of oxidation products of β-carotene at boiling temperature. *Chemistry and Physics of Lipids*. 165, 277 - 281.

Zhang, H., Zhang, J., Zhang, C., Liu, F., and Zhang, D. (2009). Degradation of C.I. Acid Orange 7 by the advanced Fenton process in combination with ultrasonic irradiation. *Ultrasonics Sonochemistry*, 16, 325 - 330.

Zhang, H., Fu, H., and Zhang, D. (2009). Degradation of C.I. Acid Orange 7 by ultrasound enhanced heterogeneous Fenton-like process. *Journal of Hazardous Materials*, 172, 654 - 660.

Zhang, X., Yong, F., Zhiyi, L., and Zongchang, Z. (2009). The Numerical Simulation of Collapse Pressure and Boundary of the Cavity Cloud in Venturi. *Chinese Journal of Chemical Engineering*, 17, 6, 896 - 903.

Zhou, Z.A., Xu, Z., Finch, J.A., Masliyah, J.H., and Chow, R.S. (2009). On the role of cavitation inparticle collection in floatation - A critical review. II. *Minerals Engineering*. 22, 419 - 433.

Zhang, Y.J., Yan, L., Chi, L., Long, X.H., Mei, Z.J., and Zhang, Z.J. (2008). Startup and operation of anaerobic EGSB reactor treating palm oil mill effluent. *Journal of Environmental Sciences-China*. 20, 658-663.

Zinatizadeh, A.A.L., Mohamed, A.R., Mashitah, M.D., Abdullah, A.Z., and Hasnain Isa, M. (2007a). Optimization of pre-treated palm oil mill effluent digestion in an up-flow anaerobic sludge fixed film bioreactor. *Biochem. Eng. J*. 35, 226 – 237.

Zinatizadeh, A.A.L., Salamatinia, B., Zinatizadeh, S.L., Mohamed, A.R., and Hasnain Isa, M. (2007b). Palm oil mill effluent digestion in an up-flow anaerobic sludge fixed film bioreactor. *Int. J. Environ. Res*. 1, 264 – 271.

Zinatizadeh, A.A.L., Mohamed, A.R., Najafpour, G.D., Isa, M.H., and Nasrollahzadeh, H. (2006). Kinetic evaluation of palm oil mill effluent digestion in a high rate up-flow anaerobic sludge fixed film bioreactor. *Process Biochemistry*. 41, 1038 – 1046.

Zimmo, O.R., van der Steen, N.P., and Gijzen, H.J. (2003). Comparison of ammonia volatilisation rates in algae and duckweed-based waste stabilisation ponds treating domestic wastewater. *Water Research*. 37, 4587 – 4594.

Zinjarde, S.S., and Pant, A. (2000). Crude oil degradation by free and immobilized cells of *Yarrowia Lipolytica NCIM 3589*. *Journal of Environmental Science and Health, Part A.* 35, 5, 755-763.