# KINETIC STUDIES FOR PHYCOREMEDIATION AND NUTRIENT REMOVAL BY *Chlorella sorokiniana* OF PALM OIL MILL EFFLUENT

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

Faculty of Biosciences and Medical Engineering
Universiti Teknologi Malaysia

DECEMBER 2017

The research work is specially dedicated to my parent

**ACKNOWLEDGEMENT**

All thank be to Almighty Allah, the helper, the forgiver, the owner of all knowledge and the one who guide me through this research project and make it possible for me to finish it successfully.

I would like to thank the effort of my main supervisor in the person of Dr. Shaza Eva Mohamad who contributed immensely to the development of the concept of the study, gave me ceaseless encouragement, advice, kindness and financial support. I thank Dr. Haryati Jamaluddin, my co-supervisor, who contributed greatly towards the success of this project. I wish to thank Dr. Adibah Binti Yahya, Prof Zaharah Ibrahim and Assoc. Prof Madihah Md. Salleh for their scientific contributions and useful comment. Thank you for sharing the knowledge and timely guidance had spent.

I wish to thank the effort of my friends and family for their ceaseless prayers, love, and guidance. Indeed, you have shown much care to me and that contribution shall never perish in memory *In-sha Allah*.

I am indebted to my respective parent; Alhaji Saidu Puma Deba and Hajiya Amina Saidu and brother and sisters; Mohammed Saidu, Isa Saidu, Adamu Saidu and Hadiza Saidu for their prayer, financial support and advice toward the completion of this program.

Lastly, I sincerely appreciate the effort of my fellow Ph.D. colleagues who devoted their time in giving their maximum contributing in order to see the success of this research work; Indeed am lucky to have you as friends.

# ABSTRACT

Palm Oil Mill Effluent (POME) is an untreated wastewater that is generated from palm oil industry containing high amount of nutrients such as nitrate, phosphate, ammonium and chemical oxygen demand (COD). Untreated effluent discharge into watercourse produce carcinogenic by-products in drinking water. In addition, eutrophication can cause oxygen deficiency in water thereby affecting the aquatic microorganisms. POME treatment using microalgae has been considered a more biofriendly system, however, high amount of nutrients affect the growth of microalgae. Hence, the present study investigates the effectiveness of robust *Chlorella sorokiniana* for pollutants removal in different dilutions of sterilized and raw POME. Standard and pyrosequencing methods were used in this study. The results for the former showed higher removal of nitrate, phosphate, ammonium and COD in raw POME than sterilized POME with the 80% (v/v) dilution been the best dilution accounting for higher growth and nutrients removal by *C. sorokiniana*. While results from the latter revealed the presence of *Bacillaceae, Paenibacillaceae, Enterococcaceae, Clostridiaceae, Peptostreptococcaceae, Caulobacteraceae, Enterobacteriaceae, Moraxellaceae and Pseudomonadaceae* bacterial families in raw POME. In addition, study of the biokinetic coefficients using Michaelis-Menten rate expression in optimal sterilized POME dilution showed that, the biokinetic coefficients of nitrate was; {k=$9.2*10^{-3}$ mg $NO_3^-$ $mg^{-1}$ dry cell weight (DCW), $d^{-1}$, $K_m$= 68.7 mg/L, $Y_N$=0.1 g DCW $g^{-1}$ $NO_3^-$}, for phosphate; {k=$8*10^{-3}$ mg $PO_4^{3-}$ $mg^{-1}$ DCW $d^{-1}$ and $K_m$=144.6 mg/L, $Y_P$= 0.12 g DCW $g^{-1}$ $PO_4^{3-}$}, for ammonium; {k=$2.3*10^{-2}$ mg $NH_4^+$ $mg^{-1}$ DCW $d^{-1}$, $K_m$= 113 mg/L, $Y_N$= , 0.08 g DCW $g^{-1}$ $NH_4^+$} and for COD {k= 0.15 mg COD $mg^{-1}$ DCW $d^{-1}$ and $K_m$ =1662 mg/L, $Y_{COD}$= 0.02 g DCW $g^{-1}$ COD for COD}. Transesterification reaction was also carried out on the biomass for fatty acid methyl ester (FAME) production. The gas chromatography-mass spectrometer (GC-MS) conducted revealed the presence of saturated FAME in algae oil which includes tridecyclic acid, myristic acid, pentadecyclic, palmitic acid and stearic acid. Based on the effect of different nitrogen sources on biomass and lipid production, urea feed of 1 and 2 g/L was identified as the optimal concentration for maximum lipid and biomass production respectively. This study is the first report of the potential of *C. sorokiniana* for POME treatment with FAME production.

# ABSTRAK

Efluen kilang kelapa Sawit (POME) adalah air kumbahan yang tidak dirawat yang dihasilkan daripada industri minyak sawit yang mengandungi jumlah nutrisi yang tinggi seperti nitrat, fosfat, ammonium dan permintaan oksigen kimia (COD). Pelepasan sisa cecair ini ke dalam saluran air tanpa rawatan menghasilkan produk sampingan yang bersifat karsinogenik dalam air minuman. Di samping itu, eutrofikasi dapat menyebabkan kekurangan oksigen dalam air sehingga mempengaruhi mikroorganisma akuatik. Rawatan POME menggunakan mikroalga telah dianggap sebagai sistem mesra-bio, namun jumlah nutrisi yang tinggi mempengaruhi pertumbuhan mikroalga. Oleh itu, kajian ini mengkaji keberkesanan Klorela sorokiniana yang kuat untuk menyingkirkan pencemar yang berbeza daripada POME yang steril dan mentah. Kaedah standard dan piro-penjujukan digunakan dalam kajian ini. Keputusan yang lepas menunjukkan penambahan nitrat, fosfat, ammonium dan COD yang lebih tinggi daripada POME mentah daripada POME yang disterilkan dengan pencairan 80% (v/v) merupakan yang terbaik bagi pertumbuhan yang lebih tinggi dan penyingkiran nutrien oleh C. sorokiniana. Selain itu, keputusan terakhir mendedahkan kehadiran *Bacillaceae, Paenibacillaceae, Enterococcaceae*, *Clostridiaceae, Peptostreptococcaceae*, *Caulobacteraceae, Enterobacteriaceae, Moraxellaceae* dan keluarga bakteria *Pseudomonadaceae* dalam POME mentah. Kajian koefisien biokinetik menggunakan ungkapan kadar Michaelis-Menten dalam pencairan POME yang disterilkan secara optimum menunjukkan bahawa koefisien nitrat biokinetik adalah; {k = $9.2 * 10^{-3}$ mg $NO_3^-$ $mg^{-1}$ berat sel kering (DCW), $d^{-1}$, $K_m$ = 68.7 mg/L, $Y_N$ = 0.1 g DCW $g^{-1}$ $NO_3^-$} untuk fosfat; {k = $8*10^{-3}$ mg $PO_4^{3-}$ $mg^{-1}$ DCW $d^{-1}$ dan $K_m$ = 144.6 mg/L, $Y_P$ = 0.12 g DCW $g^{-1}$ $PO_4^{3-}$}, untuk ammonium; {k = $2.3*10^{-2}$ mg $NH_4^+$ $mg^{-1}$ DCW $d^{-1}$, $K_m$ = 113 mg L, $Y_N$ =, 0.08 g DCW $g^{-1}$ $NH_4^+$} dan $K_m$ = 1662 mg / L, $Y_{COD}$ = 0.02 g DCW $g^{-1}$ COD untuk COD}. Reaksi transesterifikasi juga dilakukan pada biomas untuk pengeluaran metil ester asid lemak (FAME). Hasil daripada kromatografi gas-spektrometer massa (GC-MS) menunjukkan kehadiran metil ester asid lemak tepu (FAME) dalam minyak alga yang merangkumi asid tridesiklik, asid miristik, pentadesiklik, asid palmitik dan asid stearik. Berdasarkan kesan sumber nitrogen yang berbeza pada pengeluaran biomas dan lipid, penyediaan urea sebanyak 1 dan 2 g / L masing-masing telah dikenal pasti sebagai kepekatan yang optimum untuk pengeluaran lipid dan biojisim secara maksimum. Kajian ini merupakan laporan kajian pertama tentang potensi *C. sorokiniana* untuk rawatan POME dengan pengeluaran FAME.

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# LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| ACCase | - | Acetyl-CoA carboxylase |
| ADP | - | Adenosine diphosphate |
| APHA | - | American public health association |
| ATR | - | Acid transesterification reaction |
| ASTM | - | American society for testing and materials |
| ATP | - | Adenosine triphosphate |
| BOD | - | Biological oxygen demand |
| BTR | - | Basic transesterification |
| *C. sorokiniana* | - | *Chlorella sorokiniana* |
| COD | - | Chemical oxygen demand |
| DCW | - | Dry cell weight |
| DNA | - | Deoxyribonucleic acid |
| EDTA | - | Ethylenediaminetetraacetic Acid |
| ETR | - | Enzyme catalysed transesterification |
| FAEE | - | Fatty acid ethyl ester |
| FAME | - | Fatty acid methyl ester |
| FAP | - | Facultative anaerobic pond |
| FFA | - | Free fatty acid |
| GC-MS | - | Gas chromatography-mass spectrometer |
| ICP-OES | - | Inductive coupled plasma optical emission spectroscopy |
| ISO | - | International standards organization |
| kW | - | Kilowatts |
| MLSS | - | Mixed liquor suspended solid |
| MLVSS | - | Mixed liquor volatile suspended solid |
| NADPH | - | Nicotinamide adenine dinucleotide |

| | | |
|---|---|---|
| NTU | - | Nephelometric units |
| OD | - | Optical density |
| PCR | - | Polymerase chain reaction |
| pH | - | Potential of hydrogen |
| POME | - | Palm oil mill effluent |
| RF | - | Radiative forcing |
| RPM | - | Rotation per time |
| SEM | - | Scanning electron microscope |
| SLP | - | Solvent lipid complex |
| ssDNA | - | Single-stranded DNA |
| sp. | - | Species |
| TAG | - | Triacylglyceride |
| UV | - | Ultraviolet |

# LIST OF SYMBOLS

| | | |
|---|---|---|
| $CuSO_4.5H_2O$ | - | Copper Sulphate |
| $Co(NO_3)_2.6H_2O$ | - | Cobalt (II) Nitrate Hexahydrate |
| $CO_2$ | - | Carbon dioxide |
| $FeSO_4.7H_2O$ | - | Iron (II) Sulfate Heptahydrate |
| g/L | - | Gram per Litre |
| g | - | Gram |
| $H_3BO_3$ | - | Boric acid |
| $H_2SO_4$ | - | Sulphuric acid |
| $HNO_3$ | - | Nitric acid |
| KOH | - | Potassium hydroxide |
| $K_m$ | - | Saturation rate constant |
| mL | - | Millilitre |
| $MnCl_2.4H_2O$ | - | Manganese (II) Chloride Tetrahydrate |
| $MoO_3$ | - | Molybdenum (VI) oxide |
| $NH_4^+$ | - | Ammonium |
| NaOH | - | Sodium Hydroxide |
| $NO_3^-$ | - | Nitrate |
| $NO_2^-$ | - | Nitrite |
| $PO_4^{3-}$ | - | Phosphate |
| % | - | Percentage |
| $k$ | - | Reaction/Removal rate constant |
| Y | - | Yield coefficient |
| $Y_P$ | - | Yield coefficient of phosphate removal |
| $Y_N$ | - | Yield coefficient of nitrate removal |
| $Y_{COD}$ | - | Yield coefficient of COD removal |
| $R_x$ | - | Specific rate of substrate removal |

| | | |
|---|---|---|
| v/v | - | Volume by volume |
| $^{o}C$ | - | Degree centigrade |
| ρ | - | Density |
| μm | - | Micrometre |
| μmol | - | Micromole |
| $ZnSO_4.7H_2O$ | - | Zinc Sulfate Heptahydrate |

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# CHAPTER 1

# INTRODUCTION

## 1.1 Background of the Research

Due to rapid industrialisation which in effect had caused high levels of pollution especially of water systems, there has been an increased interest in the discovery of microphytes to mitigate pollution concentrations in contaminated waters. Most water pollution arose from the discharge of wastewater from a piggery, dairy, refinery, textile and palm oil industry (Abdullah *et al.*, 2013). Palm oil industries in Malaysia have grown rapidly over the years (Neoh *et al.*, 2013). The various processes of palm oil mill production (sterilization, stripping, digestion, pressing and clarification) lead to the generation of wastewater known as palm oil mill effluent (POME) (Lam and Lee, 2011). A great deal of concern on the quality and quantity of POME generated and discharge into natural water bodies have recently indicated the need for better treatment strategy to handle water pollution. POME contained high amount of nitrogen, phosphorus, Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Total Solid (TS) and Suspended Solid (SS).

The release of such high chemical effluent poses serious environmental challenges such as eutrophication to the receiving water bodies (De-Bashan and Bashan, 2010; de Godos *et al.*, 2009; Munoz and Guieysse, 2006). Conventional treatment systems such as ponding system, anaerobic digestion, mechanical aeration, activated sludge system and chemical method was currently under practice, however, these are methods that suffer many disadvantages such as poor pollutants removal, generation of secondary pollutants and expensive to practice. One promising approach to achieve effective bioremediation and energy reduction during the treatment is to integrate algal facility within the existing industrial wastewater treatment system. This implies that the wastewater was used as feed for microalgae growth. The advantage of this system is that while the microalgae remove excess nutrients in the wastewater, there will be a concomitant accumulation of biomass for downstream processing (Chinnasamy *et al.*, 2010b; Olguí, 2003; Rawat *et al.*, 2011). The major nutrients required for the cultivation of algal cell is basically nitrogen and phosphorus and they are contained in wastewater. This kind of industrial symbiosis can critically decline the economic and environmental cost of wastewater treatment plant. Thus, phycoremediation which uses naturally occurring microorganism to treat the industrial wastewater and this treatment process can prove less expensive with no secondary production of pollution and easier to handle than other technologies employed to clean up hazardous waste (de Godos *et al.*, 2009; Kshirsagar, 2013).

Microalgae are microscopic plant belonging to both prokaryotic and eukaryotic microorganism. The prokaryotic algae are the cyanobacteria that resemble typical bacteria. The three most important classes of eukaryotic algae are basically diatoms (Bacillariophyceae), green algae (Chlorophyceae) and the golden algae (Chrysophyceae) (Saidu *et al.*, 2017). Their unicellular feature gives them competitive advantages of converting about 50% of global carbon present in the atmosphere. Microalgae exist in chain or individually with no root, stem and leave (Mondal *et al.*, 2016). The presence of green pigment allows them to conduct photosynthesis using available sunlight and nutrients and therefore grow rapidly. Although most of the microalgae species live in freshwater and marine environment, there are few other microalgae species that can grow under harsh and unfavourable environmental conditions. Some species of microalgae contained a robust cell wall which enables them to withstand unfavourable condition (Sahay and Braganza, 2016). Depending on the species, some microalgae can acclimatize to different environmental changes which are due to their ability to produce chemical substances in order to neutralize the effect of this environmental changes. From a practical point of view, many of their species are easy to cultivate because they are not too demanding of constant monitoring especially in water that is rich in nutrients and unsuitable for human use. In addition, an increase in the concentration of the nutrients was also reported to increase their growth cycle (Choudhary *et al.*, 2016). As a result of that, microalgae has recently been fully incorporated as an important bioremediation agent and are already been used by many wastewater facilities.

Although the main focus of this research is to evaluate the viability of using microalgae for nutrients stripping in POME, it is of high crucial to put into consideration the utilization of the cultivated biomass post-wastewater treatment. Many species of microalgae had evolved to produce biomass which contains high amount of lipid with the potential of converting it to biodiesel (an alternative to petroleum-based diesel) (Ahmad *et al*., 2016). Fatty acid methyl ester (FAME) is a renewable form of bio-energy that fulfilled the promise of providing an alternative source of energy and future reduction of environmental pollution. This is why the continuous use of petroleum-based fuels is now widely recognized as unsustainable because of depleting supplies and the contribution of these fuels to the accumulation of carbon dioxide in the environment (Li *et al.*, 2011b; Luthfi *et al.*, 2017). Literature has stated that high productivity of lipid is strongly correlated with the growth of algae in a particular growth medium (Bertoldi *et al.*, 2006). It is therefore suggested that the use of wastewater as an algae growth substrate will go a long way in reducing the operational cost of algae cultivation. For instance, *C. vulgaris* was demonstrated to grow on artificial medium resulted in 20-42% (dry biomass) lipid while reported to have nutrients removal efficiency for ammonium and phosphorus to be 97% and 96% respectively (Feng *et al.*, 2011). Nevertheless, studies have reported the occurrence of some algal species with the ability to removed nutrients and have high lipid content when grown in wastewater (Kamyab *et al.*2015; Lekshmi *et al.*, 2015; Wang *et al.*, 2010b). Specifically, on POME, a very limited research on its treatment using microalgae exist (Ding *et al.*, 2016a; Hadiyanto and Nur, 2012). Yet, none of this literatures reported the use of mixotrophic microalgae species belonging to particular genera identified to have robust cell wall and lipid-rich such as *Chlorella sorokiniana* for simultaneous treatment of POME under sterilized and raw conditions, coupled with biodiesel production. This species grow mixotrophically, giving it the ability to grow well in a strange environment. The aim of this research is to assess the potential of utilizing *C. sorokiniana* for the treatment of POME. By conducting a biokinetic study for pollutants removal from POME, a comprehensive understanding of the biological processes taking place during the treatment can be obtained. As microalgae wastewater treatment, hold a promise of proving zero waste generation, the biomass of wastewater-grown algae will be investigated for lipid and fatty acid methyl ester (FAME). This is a one-step strategy of achieving effective phycoremediation and developing the sustainability of biofuel production.

## 1.2 Statement of Problem

Malaysia is the second producers of palm oil across the globe (Lam and Lee, 2011). During the processing activities of palm oil in the palm oil industry, about 5-7.5 tonne of water is required for the production of 1 tonne of crude palm oil, and more than 50% of the used water produce POME (Ahmad *et al*., 2016). The presence of high amount of nitrates, phosphate, chemical oxygen demand and ammonium in POME affects both human, aquatic biota and the surrounding environment. It causes eutrophication which promotes excessive growth of algae and causes oxygen depletion in water body thereby threatening the life of the aquatic organisms (Cai *e al*., 2013). The conventional treatment methods of POME include vermicomposting, mechanical aeration, anaerobic digestion and ponding system. However, these are methods that suffer disadvantages such as inefficiency for pollutants removal, expensive to practice and introduction of secondary pollutant into the environment. Therefore the ultimate solution of finding an efficient method that can remove pollutants from POME with no production of secondary pollutant is to utilize the biological method, and the use of microalgae in this case can provide dual role of efficient POME treatment and production of valuable biomass.

The major challenges of using microalgae for POME treatment are slow rate of pollutant removal, which therefore prolongs the complete removal of these pollutants in POME. Therefore microalgae that have the ability to remove organic pollutant by both assimilatory and dissimilatory process are adequately required in wastewater treatment plant. During the process of assimilatory and dissimilatory activity, nitrate and phosphate are been converted into ammonium and orthophosphate respectively in the algal cell before they are utilized for growth (Cai *et al*., 2013). These processes are considered useful more especially to a situation where there is need to utilize the captured nitrate and phosphate in the algal biomass for the production of value-added substances.

The large volumes of the biomass that are left after POME treatment are mostly left to decay with the aim of improving the soil fertility (Kamyab *et al*., 2014). This is considered unacceptable by the local community as it causes aesthetic pollution to the environment. A quite remarkable opportunity is the utilization of wastewater grown algal biomass as a promising feedstock for biodiesel production. This will add more value to the economy of biofuel production in terms of reducing the over-dependence on food crop as a feedstock for bioenergy production. Another key problem hindering the up-scaling of algae-based biofuel production is high cost of production due to unusual cultivating system (Doma *et al*., 2016). The use of POME as medium will completely eradicate the need for cultivating medium (synthetic) which will reduce the cost of biodiesel production in the biodiesel industry.

## 1.3 Objectives of the Research

The objectives of the research are;

i. To analyze the performance of *Chlorella sorokiniana* for nutrients removal in POME under sterilized and raw condition.
ii. To study the biokinetic coefficients of nitrate, phosphate, ammonium and COD removal in the best-diluted POME by *Chlorella sorokiniana.*
iii. To investigate the potential of wastewater-grown microalgae for the production lipid and fatty acid methyl ester (FAME).

## 1.4 Scope of the Research

The project gave more priority on the cultivation of *C. sorokiniana* in different dilutions of POME for bio-treatment and biokinetic coefficients study. The specific POME dilution that supported the maximum growth of algae was selected and subjected to the subsequent experiments. POME was first characterized according to the standard method of APHA before the commencement of phycoremediation (Apha, 2005). Various kinetic coefficients for removal of nitrate ($NO_3^-$), phosphate ($PO_4^{3-}$), ammonium ($NH_4^+$) and COD were studied for over 15 days. Next, the potential of utilizing biomass of wastewater-grown algae for lipid and fatty acid methyl ester (FAME) production was determined using solvent extraction and transesterification method. Gas chromatography-mass spectrometer (GC-MS) was used for the identification of FAME. The obtained FAME was characterized based on physical features and its quality was compared with world standard quality criteria for diesel. Next-generation sequencing (pyrosequencing) was used to identify the indigenous microbial communities that interact with microalgae during the treatment of POME under raw condition.

## 1.5 Summary of Chapter 1

The increase in wastewater discharge from various industries into the water bodies has been considered as the major causes of water pollution across the globe. In Malaysia, the rapid growth of the palm oil industries has made it the second producers of palm oil in the world. POME is a wastewater that is generated during the processing of palm oil in palm oil milling industry. POME contain high amount of chemical compounds and nutrients such as BOD, COD, nitrate, phosphate and heavy metals. The release of these chemical compounds into the water bodies affects both human and aquatic biota and therefore it is imperative to find an efficient method that will remove these pollutants before it is discharged out to the environment.

The conventional methods of POME treatment were unable to meet the regulatory discharge limit set by the Malaysian Department of Environmental (DOE) that is why using microalgae to treat POME is considered highly efficient. Microalgae are suitable for the treatment of POME because the necessary and fundamental components of their growth are mainly nitrogen and phosphorus and are adequately contained in POME wastewater. This gave microalgae the ability to remove various pollutants such as nitrogen and phosphorus from water. POME treatment using microalgae results into the production of large volume of biomass which has a potential to be used for the production of value-added production. This means that POME grown algae can be used for biofuel production.

In spite of the fact that few researches were done on the use of microalgae for POME treatment, no research reported any species of microalgae that can treat POME efficiently. Hence, this research reported the potential of utilizing *C. sorokiniana* for the treating of POME. The mechanism employed for the pollutant removal from POME was studied using Michaelis-Menten kinetic equation. The application of the biomass obtained after treatment of POME was examined for its potential for biodiesel production.

# REFERENCES


Abbaszaadeh, A., Ghobadian, B., Omidkhah, M. R. and Najafi, G. (2012). Current biodiesel production technologies: a comparative review. *Energy Conversion and Management.* 63, 138-148.

Abdel-Raouf, N., Al-Homaidan, A. and Ibraheem, I. (2012). Microalgae and wastewater treatment. *Saudi Journal of Biological Sciences*. 19(3), 257-275.

Abdullah, N., Yuzir, A., Curtis, T. P., Yahya, A. and Ujang, Z. (2013). Characterization of aerobic granular sludge treating high strength agro-based wastewater at different volumetric loadings. *Bioresource technology*. 127, 181-187.

Abou-Shanab, R. A., Ji, M.-K., Kim, H.-C., Paeng, K.-J. and Jeon, B.-H. (2013). Microalgal species growing on piggery wastewater as a valuable candidate for nutrient removal and biodiesel production. *Journal of environmental management*. 115, 257-264.

Agarwal, A. K., and Das, L. M. (2001). Biodiesel development and characterization for use as a fuel in compression ignition engines. *Transactions-american society of mechanical engineers journal of engineering for gas turbines and power*. 123(2), 440-447.

Ahmad, A., Buang, A., and Bhat, A. H. (2016). Renewable and sustainable bioenergy production from microalgal co-cultivation with palm oil mill effluent (POME): a review. *Renewable and Sustainable Energy Reviews*. 65, 214-234.

Ahmad, A.L., Mat, Y.N.H., Derek, C.J.C. and Lim, J.K. (2011). Microalgae as a sustainable energy source for biodiesel production: a review. *Renewable and Sustainable Energy Review*. 15, 584–93.

Ajanovic, A. (2011). Biofuels versus food production: does biofuels production increase food prices? *Energy*. 36(4), 2070-2076.

Ajayan, K. V., Selvaraju, M., Unnikannan, P. and Sruthi, P. (2015). Phycoremediation of tannery wastewater using microalgae *Scenedesmus* species. *International journal of phytoremediation*. 17(10), 907-916.

Al-lwayzy, S. H., Yusaf, T. and Al-Juboori, R. A. (2014). Biofuels from the fresh water microalgae *Chlorella vulgaris* (FWM-CV) for diesel engines. *Energies*. 7(3), 1829-1851.

Alptekin, E. and Canakci, M. (2008). Determination of the density and the viscosities of biodiesel–diesel fuel blends. *Renewable Energy*. 33(12), 2623-2630.

Amin, S., Hmelo, L., Van Tol, H., Durham, B., Carlson, L., Heal, K., Morales, R., Berthiaume, C., Parker, M. and Djunaedi, B. (2015). Interaction and signalling between a cosmopolitan phytoplankton and associated bacteria. *Nature*. 522(7554), 98-101.

Anastopoulos, G., Zannikou, Y., Stournas, S. and Kalligeros, S. (2009). Transesterification of vegetable oils with ethanol and characterization of the key fuel properties of ethyl esters. *Energies*. 2(2), 362-376.

Andersen, R. (2005). Algal cultural techniques. Phycological Society of America. Elsevier.

Ansari, F. A., Singh, P., Guldhe, A. and Bux, F. (2017). Microalgal cultivation using aquaculture wastewater: Integrated biomass generation and nutrient remediation. *Algal Research*. 21, 169-177.

APHA. (1998). Standard Methods for the Examination of Water and Wastewater. 20th ed. Washington, D.C.: *American Public Health Association*, American Water Works Association, and Water Environment Federation.

Aransiola, E. F., Ojumu, T. V., Oyekola, O. O., Madzimbamuto, T. F., and Ikhu-Omoregbe, D.I.O. (2014). A review of current technology for biodiesel production: State of the art. *Biomass and bioenergy.* 61, 276-297.

Aslan, S. and Kapdan, I. K. (2006). Batch kinetics of nitrogen and phosphorus removal from synthetic wastewater by algae. *Ecological Engineering*. 28(1), 64-70.

Association, A. P. H. (1994). Water Environment Federation (1998) Standard methods for the examination of water and wastewater. Washington, Dc.

Atadashi, I. M., Aroua, M. K., Aziz, A. A., and Sulaiman, N. M. N. (2013). The effects of catalysts in biodiesel production: A review.*Journal of industrial and engineering chemistry.* 19(1), 14-26.

Ayetor, G. K., Sunnu, A. and Parbey, J. (2015). Effect of biodiesel production parameters on viscosity and yield of methyl esters: *Jatropha curcas*, *Elaeis guineensis* and *Cocos nucifera*. *Alexandria Engineering Journal*. 54(4), 1285-1290.

Azad, A. K., Rasul, M., Khan, M. M. K. and Sharma, S. C. (2014). Review of non-edible biofuel resources in Australia for second generation (2G) biofuel conversion. *Proceedings of the 2014 International Green Energy Conference, Tianjin, China*, 867-878.

Bala, J. D., Lalung, J. and Ismail, N. (2015). Studies on the reduction of organic load from palm oil mill effluent (POME) by bacterial strains. *International Journal of Recycling of Organic Waste in Agriculture*. 4(1), 1-10.

Bamgboye, A. I. and Hansen, A. C. (2008). Prediction of cetane number of biodiesel fuel from the fatty acid methyl ester (FAME) composition. *International Agrophysics*. 22(1), 21.

Barabás, I. and Todoruţ, I-A. (2011). Biodiesel Quality, Standards and Properties, Biodiesel-Quality, Emissions and By-Products, Dr. Gisela Montero (Ed.), ISBN: 978-953-307-784-0, InTech, Available from: http://www.intechopen.com/books/biodiesel-quality-emissions-and-by-products/biodiesel-qualitystandards-and-properties.

Barsanti, L. and Gualtieri, P. (2014). *Algae: anatomy, biochemistry, and biotechnology*. CRC press.

Băţaga, N., Burnete, N. and Barabás, I. (2003). Combustibili, lubrifianţi, materiale speciale pentru autovehicule. Economicitate şi poluare. *Alma Mater, ISBN*. 973-9471.

Becker, E. (2007). Micro-algae as a source of protein. *Biotechnology advances*. 25(2), 207-210.

Benard, L. D. and Tuah, P. M. (2016). Biodegradation of Sabah Light Crude Oil by Locally Isolated *Candida tropicalis* RETL-Cr1 and *Pseudomonas aeruginosa* BAS-Cr1.

Berland, B., Bonin, D., Guerin-Ancey, O. and Antia, N. (1979). Concentration requirement of glycine as nitrogen source for supporting effective growth of certain marine microplanktonic algae. *Marine Biology*. 55(2), 83-92.

Bertoldi, F. C., Sant'Anna, E., da Costa Braga, M. V. and Oliveira, J. L. B. (2006). Lipids, fatty acids composition and carotenoids of *Chlorella vulgaris* cultivated in hydroponic wastewater. *Grasas y aceites*. 57(3), 270-274.

Bhatnagar, A., Chinnasamy, S., Singh, M. and Das, K. (2011). Renewable biomass production by mixotrophic algae in the presence of various carbon sources and wastewaters. *Applied Energy*. 88(10), 3425-3431.

Brown, M., Jeffrey, S., Volkman, J. and Dunstan, G. (1997). Nutritional properties of microalgae for mariculture. *Aquaculture*. 151(1-4), 315-331.

Cabanelas, I. T. D., Ruiz, J., Arbib, Z., Chinalia, F. A., Garrido-Pérez, C., Rogalla, F., Nascimento, I. A. and Perales, J. A. (2013). Comparing the use of different domestic wastewaters for coupling microalgal production and nutrient removal. *Bioresource technology*. 131, 429-436.

Cai, T., Park, S. Y. and Li, Y. (2013). Nutrient recovery from wastewater streams by microalgae: status and prospects. *Renewable and Sustainable Energy Reviews*. 19, 360-369.

Canakci, M. and H. Sanli, (2008). Biodiesel production from various feedstocks and their effects on the fuel properties. Journal of Industrial Microbiology and Biotechnology. 35, 431-441.

Carpenter, S. R., Caraco, N. F., Correll, D. L., Howarth, R. W., Sharpley, A. N. and Smith, V. H. (1998). Nonpoint pollution of surface waters with phosphorus and nitrogen. *Ecological applications*. 8(3), 559-568.

Chavalparit, O., Rulkens, W., Mol, A. and Khaodhair, S. (2006). Options for environmental sustainability of the crude palm oil industry in Thailand through enhancement of industrial ecosystems. *Environment, Development and Sustainability*. 8(2), 271-287.

Chen, C., Xu, X.-J., Xie, P., Yuan, Y., Zhou, X., Wang, A.-J., Lee, D.-J. and Ren, N.-Q. (2017). Pyrosequencing reveals microbial community dynamics in integrated simultaneous desulfurization and denitrification process at different influent nitrate concentrations. *Chemosphere*. 171, 294-301.

Chinnasamy, S., Bhatnagar, A., Claxton, R. and Das, K. (2010a). Biomass and bioenergy production potential of microalgae consortium in open and closed bioreactors using untreated carpet industry effluent as growth medium. *Bioresource Technology*. 101(17), 6751-6760.

Chinnasamy, S., Bhatnagar, A., Hunt, R. W. and Das, K. (2010b). Microalgae cultivation in a wastewater dominated by carpet mill effluents for biofuel applications. *Bioresource technology*. 101(9), 3097-3105.

Chisti, Y. (2007). Biodiesel from microalgae. *Biotechnology advances*. 25(3), 294-306.

Cho, D.-H., Ramanan, R., Heo, J., Kang, Z., Kim, B.-H., Ahn, C.-Y., Oh, H.-M. and Kim, H.-S. (2015). Organic carbon, influent microbial diversity and temperature strongly influence algal diversity and biomass in raceway ponds treating raw municipal wastewater. *Bioresource technology*. 191, 481-487.

Cho, D. H., Ramanan, R., Heo, J., Lee, J., Kim, B. H., Oh, H. M. and Kim, H. S. (2015). Enhancing microalgal biomass productivity by engineering a microalgal–bacterial community. *Bioresource technology*. 175, 578-585.

Chojnacka, K., Chojnacki, A. and Górecka, H. (2004). Trace element removal by *Spirulina* sp. from copper smelter and refinery effluents. *Hydrometallurgy*. 73(1), 147-153.

Choudhary, P., Prajapati, S. K. and Malik, A. (2016). Screening native microalgal consortia for biomass production and nutrient removal from rural wastewaters for bioenergy applications. *Ecological Engineering*. 91, 221-230.

Ciulu, M., Spano, N., Pilo, M. I. and Sanna, G. (2016). Recent advances in the analysis of phenolic compounds in unifloral honeys. *Molecules*, 21(4), 451.

Cooper, M. B. and Smith, A. G. (2015). Exploring mutualistic interactions between microalgae and bacteria in the omics age. *Current opinion in plant biology*. 26, 147-153.

Craggs, R., Heubeck, S., Lundquist, T. and Benemann, J. (2011). Algal biofuels from wastewater treatment high rate algal ponds. *Water Science and Technology*. 63(4), 660-665.

Dash, A. and Banerjee, R. (2017). Enhanced biodiesel production through phyco-myco co-cultivation of *Chlorella minutissima* and *Aspergillus awamori*: An integrated approach. *Bioresource technology*. 238, 502-509.

De-Bashan, L. E. and Bashan, Y. (2010). Immobilized microalgae for removing pollutants: review of practical aspects. *Bioresource technology*. 101(6), 1611-1627.

de Godos, I., Blanco, S., García-Encina, P. A., Becares, E. and Muñoz, R. (2009). Long-term operation of high rate algal ponds for the bioremediation of piggery wastewaters at high loading rates. *Bioresource Technology*. 100(19), 4332-4339.

Demirbas, A. and Demirbas, M. F. (2011). Importance of algae oil as a source of biodiesel. *Energy conversion and management*. 52(1), 163-170.

Derner, R. B., Ohse, S., Villela, M., Carvalho, S. M. d. and Fett, R. (2006). Microalgae, products and applications. *Ciência Rural*. 36(6), 1959-1967.

Desjardins, P. and Conklin, D. (2010). NanoDrop microvolume quantitation of nucleic acids. *Journal of visualized experiments: JoVE*, (45).

Ding, G. T., Yaakob, Z., Takriff, M. S., Salihon, J. and Rahaman, M. S. A. (2016a). Biomass production and nutrients removal by a newly-isolated microalgal strain *Chlamydomonas* sp in palm oil mill effluent (POME). *International Journal of Hydrogen Energy*. 41(8), 4888-4895.

Ding, J., Zhao, F., Cao, Y., Xing, L., Liu, W., Mei, S. and Li, S. (2015). Cultivation of microalgae in dairy farm wastewater without sterilization. *International journal of phytoremediation*. 17(3), 222-227.

Dlugokencky, E. and Tans, P. (2015). "ESRL Global Monitoring Division". *Earth System Research Laboratory*. National Oceanic & Atmospheric Administration. Retrieved7 May 2015.

Doma, H. S., El-Liethy, M. A., Abdo, S. M. and Ali, G. H. (2016). Potential of using high rate algal pond for algal biofuel production and wastewater treatment. *Asian Journal of Chemistry*. 28(2), 399.

Dönmez, G. Ç., Aksu, Z., Öztürk, A. and Kutsal, T. (1999). A comparative study on heavy metal biosorption characteristics of some algae. *Process biochemistry*. 34(9), 885-892.

Dragone, G., Fernandes, B.D., Abreu, A.P., Vicente, A.A. and Teixeira, J.A. (2011). Nutrient limitation as a strategy for increasing starch accumulation in microalgae. *Applied Energy*. 88(10), 3331–3335.

Dwivedi, G. and Sharma, M. P. (2016). Experimental investigation on thermal stability of pongamia biodiesel by thermogravimetric analysis. *Egyptian Journal of Petroleum*. 25(1), 33-38.

El-Bestawy, E. (2008). Treatment of mixed domestic–industrial wastewater using cyanobacteria. *Journal of industrial microbiology & biotechnology*. 35(11), 1503-1516.

El-Sheekh, M. M., El-Shouny, W. A., Osman, M. E. and El-Gammal, E. W. (2005). Growth and heavy metals removal efficiency of *Nostoc muscorum* and *Anabaena subcylindrica* in sewage and industrial wastewater effluents. *Environmental toxicology and pharmacology*. 19(2), 357-365.

Elumalai, S., Sangeetha, T. and Roop Singh, D. (2015). *Botryococcus braunii* as a Phycoremediation Tool for the Domestic Waste Water Recycling from Cooum River, Chennai, India. *J. Bioremediation Biodegrad.* 6.

Ergashev, A. and Tajiev, S. (1986). Seasonal Variations of Phytoplankton in a Series of Waste Treatment Lagoons (Chimkent, Central Asia) Part 2: Distribution of Phytoplankton Numbers and Biomass. *Acta hydrochimica et hydrobiologica*. 14(6), 613-625.

Federation, W. E. and Association, A. P. H. (2005). Standard methods for the examination of water and wastewater. *American Public Health Association (APHA): Washington, DC, USA.*

Feng, Y., Li, C. and Zhang, D. (2011). Lipid production of *Chlorella vulgaris* cultured in artificial wastewater medium. *Bioresource technology*. 102(1), 101-105.

Fergola, P., Cerasuolo, M., Pollio, A., Pinto, G. and DellaGreca, M. (2007). Allelopathy and competition between *Chlorella vulgaris* and *Pseudokirchneriella subcapitata*: experiments and mathematical model. *Ecological Modelling*. 208(2), 205-214.

Ferrari, R. A., Oliveira, V. D. S., and Scabio, A. (2005). Biodiesel de soja–taxa de conversão em ésteres etílicos, caracterização físico-química e consumo em gerador de energia. *Química Nova*,28(1), 19-23.

Frampton, D. M., Gurney, R. H., Dunstan, G. A., Clementson, L. A., Toifl, M. C., Pollard, C. B., Burn, S., Jameson, I. D. and Blackburn, S. I. (2013). Evaluation of growth, nutrient utilization and production of bioproducts by a wastewater-isolated microalga. *Bioresource technology*. 130, 261-268.

Francisco, E.C., Neves, D.B., Jacob-Lopes, E. and Franco, T.T. (2010). Microalgae as feedstock for biodiesel production: carbon dioxide sequestration, lipid production and biofuel quality. *Journal of Chemical Technology and Biotechnology*. 85, 395–403.

Fukuda, H., Kondo, A. and Noda, H. (2001). Biodiesel fuel production by transesterification of oils. *Journal of bioscience and bioengineering*. 92(5), 405-416.

Furtado, A. L. F. F., do Carmo Calijuri, M., Lorenzi, A. S., Honda, R. Y., Genuário, D. B. and Fiore, M. F. (2009). Morphological and molecular characterization of cyanobacteria from a Brazilian facultative wastewater stabilization pond and evaluation of microcystin production. *Hydrobiologia*. 627(1), 195-209.

Gadd, G. M. (2009). Biosorption: critical review of scientific rationale, environmental importance and significance for pollution treatment. *Journal of Chemical Technology and Biotechnology*. 84(1), 13-28.

Gani, P., Sunar, N. M., Matias-Peralta, H., Mohamed, R. M. S. R., Latiff, A. A. A. and Parjo, U. K. (2017). Extraction of hydrocarbons from freshwater green microalgae (*Botryococcus* sp.) biomass after phycoremediation of domestic wastewater. *International Journal of Phytoremediation*. 19(7), 679-685.

García-Balboa, C., Baselga-Cervera, B., García-Sanchez, A., Igual, J. M., Lopez-Rodas, V. and Costas, E. (2013). Rapid adaptation of microalgae to bodies of water with extreme pollution from uranium mining: an explanation of how mesophilic organisms can rapidly colonise extremely toxic environments. *Aquatic toxicology*. 144, 116-123.

Gashaw, A., Getachew, T. and Teshita, A. (2015). A Review on biodiesel production as alternative fuel. *Journal For Production of Industry.* 4, 80-85.

Gates, W. and Borchardt, J. (1964). Nitrogen and phosphorus extraction from domestic wastewater treatment plant effluents by controlled algal culture. *Journal (Water Pollution Control Federation)*. 443-462.

Gerphagnon, M., Latour, D., Colombet, J. and Sime-Ngando, T. (2013). Fungal parasitism: life cycle, dynamics and impact on cyanobacterial blooms. *PloS one*. 8(4), e60894.

Gerwick, W.H., Tan, L. and Sitachitta, N. (2001). Nitrogen-containing metabolites from marine cyanobacteria. In Cordell, G.A. (ed.) The Alkaloids. San Diego: *Academic Press*; p75-184.

Giersdorf, J. (2013). Politics and economics of ethanol and biodiesel production and consumption in Brazil, DBFZ.

Gola, D., Chauhan, N., Malik, A. and Shaikh, Z. A. (2017). Bioremediation Approach for Handling Multiple Metal Contamination *Handbook of Metal-Microbe Interactions and Bioremediation* (pp. 471-491)CRC Press.

Gomez-Guzman, A.I.P., Jimenez-Magana, S., Gomez-Hermosillo, C., Perez-Luna, V., Parra-Rodriguez, F.J., Suggey Guerra-.Renteria, B., Aguilar-Uscanga, R., Solis-Pacheco, J. and Gonzalez-Reynoso O. (2016). Evaluation of nutrients removal ($NO_3$-N, $NH_3$-N and PO4-P) with *Chlorella vulgaris*, *Pseudomonas putida*, *Bacillus cereus* and the consortium of these microorganisms in the secondary treatment of municipal wastewater effluents. *J Biotechnol Biomater.* 6:8,. 13$^{th}$ Biotechnology congress; San Francisco, USA. http://dx.doi.org/10.4172/2155-952X.C1.068.

Gonzalez, L. E. and Bashan, Y. (2000). Increased Growth of the Microalga *Chlorella vulgaris* when Coimmobilized and Cocultured in Alginate Beads with the Plant-Growth-Promoting Bacterium *Azospirillum brasilense*. *Applied and Environmental Microbiology*. 66(4), 1527-1531.

Grady, C. L., Smets, B. F. and Barbeau, D. S. (1996). Variability in kinetic parameter estimates: a review of possible causes and a proposed terminology. *Water Research*. 30(3), 742-748.

Guldhe, A., Ansari, F. A., Singh, P. and Bux, F. (2017). Heterotrophic cultivation of microalgae using aquaculture wastewater: A biorefinery concept for biomass production and nutrient remediation. *Ecological Engineering*. 99, 47-53.

Guldhe, A., Singh, B., Rawat, I., Ramluckan, K. and Bux, F. (2014). Efficacy of drying and cell disruption techniques on lipid recovery from microalgae for biodiesel production. *Fuel*. 128, 46-52.

Gupta, S. K., Ansari, F. A., Shriwastav, A., Sahoo, N. K., Rawat, I. and Bux, F. (2016). Dual role of *Chlorella sorokiniana* and *Scenedesmus obliquus* for comprehensive wastewater treatment and biomass production for bio-fuels. *Journal of Cleaner Production*. 115, 255-264.

Gupta, V., Ratha, S. K., Sood, A., Chaudhary, V. and Prasanna, R. (2013). New insights into the biodiversity and applications of cyanobacteria (blue-green algae)—prospects and challenges. *Algal research*. 2(2), 79-97.

Hadiyanto, N. M. and Nur, M. (2012). Potential of Palm Oil Mill Effluent (POME) as Medium Growth of *Chlorella* sp for Bioenergy Production. *Int J Env an d Bioenerg*. 3(2), 67-74.

Halim, R., Gladman, B., Danquah, M. K. and Webley, P. A. (2011). Oil extraction from microalgae for biodiesel production. *Bioresource technology*. 102(1), 178-185.

Hammouda, O., Gaber, A. and Abdelraouf, N. (1995). Microalgae and wastewater treatment. *Ecotoxicology and Environmental safety*. 31(3), 205-210.

Hancock, L., Goff, L. and Lane, C. (2010). Red algae lose key mitochondrial genes in response to becoming parasitic. *Genome biology and evolution.* 2, 897-910.

Harley, J. P. and Prescott, L. M. (2002). Bacterial morphology and staining. *Laboratory Exercises in Microbiology, 5th Edition, The McGraw-Hill Companies, New York*, 31-36.

Harwood, J. L. (1988). Fatty acid metabolism. *Annual Review of Plant Physiology and Plant Molecular Biology*. 39(1), 101-138.

Heasman, M., Diemar, J., O'connor, W., Sushames, T. and Foulkes, L. (2000). Development of extended shelf-life microalgae concentrate diets harvested by centrifugation for bivalve molluscs–a summary. *Aquaculture Research*. 31(8-9), 637-659.

Helliwell, K. E., Wheeler, G. L., Leptos, K. C., Goldstein, R. E., and Smith, A. G. (2011). Insights into the evolution of vitamin B12 auxotrophy from sequenced algal genomes. *Molecular biology and evolution*. 28(10), 2921-2933.

Hernandez, J. P., de-Bashan, L. E., Rodriguez, D. J., Rodriguez, Y. and Bashan, Y. (2009). Growth promotion of the freshwater microalga *Chlorella vulgaris* by the nitrogen-fixing, plant growth-promoting bacterium Bacillus pumilus from arid zone soils.*european journal of soil biology*. 45(1), 88-93.

Hillebrand, H., Watermann, F., Karez, R. and Berninger, U.-G. (2001). Differences in species richness patterns between unicellular and multicellular organisms. *Oecologia*. 126(1), 114-124.

Hjelmsø, M. H., Hansen, L. H., Bælum, J., Feld, L., Holben, W. E., and Jacobsen, C. S. (2014). High-resolution melt analysis for rapid comparison of bacterial community compositions. *Applied and environmental microbiology*, *80*(12), 3568-3575.

Hoekman, S. K., Broch, A., Robbins, C., Ceniceros, E. and Natarajan, M. (2012). Review of biodiesel composition, properties, and specifications. *Renewable and Sustainable Energy Reviews*. 16(1), 143-169.

Hongyang, S., Yalei, Z., Chunmin, Z., Xuefei, Z. and Jinpeng, L. (2011). Cultivation of *Chlorella pyrenoidosa* in soybean processing wastewater. *Bioresource Technology*. 102(21), 9884-9890.

Hosmani, S. P. and Hosetti, B. B. (2009). Diversity of phytoplanktons in a waste stabilization pond at Shimoga Town, Karnataka State, India. *Environmental Monitoring and Assessment*. 151(1), 437-443.

Ho S-H, Huang, S-W., Chen, C-Y., Hasunuma, T., Kondo, A. and Chang, J-S. (2013). Bioethanol production using carbohydrate-rich microalgae biomass as feedstock. *Bioresource Technology*. 135, 191–198.

Hou, X., Amais, R. S., Jones, B. T. and Donati, G. L. (2000). Inductively coupled plasma optical emission spectrometry.*Encyclopedia of analytical chemistry.*

Hyman, E. D. (1988). A new method of sequencing DNA. *Analytical biochemistry*. 174(2), 423-436.

Ichihara, K. i. and Fukubayashi, Y. (2010). Preparation of fatty acid methyl esters for gas-liquid chromatography. *Journal of lipid research*. 51(3), 635-640.

Idi, A., Ibrahim, Z., Mohamad, S. E. and Majid, Z. A. (2015). Biokinetics of nitrogen removal at high concentrations by *Rhodobacter sphaeroides* ADZ101. *International Biodeterioration and Biodegradation*. 105, 245-251.

Illias, R., Ooi, S. and Idris, A. (1999). Isolation and characterization of thermophilic microorganisms from Malaysian oil fields. *Proceedings of the 1999 SPE annual technical conference*.

Jayakumar, S., Yusoff, M. M., Rahim, M. H. A., Maniam, G. P., and Govindan, N. (2017). The prospect of microalgal biodiesel using agro-industrial and industrial wastes in Malaysia. *Renewable and Sustainable Energy Reviews*. 72, 33-47.

Ji, F., Liu, Y., Hao, R., Li, G., Zhou, Y. and Dong, R. (2014). Biomass production and nutrients removal by a new microalgae strain *Desmodesmus* sp. in anaerobic digestion wastewater. *Bioresource technology*. 161, 200-207.

Jia, Q., Xiang, W., Yang, F., Hu, Q., Tang, M., Chen, C., Wang, G., Dai, S., Wu, H. and Wu, H. (2016). Low-cost cultivation of Scenedesmus sp. with filtered anaerobically digested piggery wastewater: biofuel production and pollutant remediation. *Journal of applied phycology*. 28(2), 727-736.

Johnson, K. R. and Admassu, W. (2013). Mixed algae cultures for low cost environmental compensation in cultures grown for lipid production and wastewater remediation. *Journal of Chemical Technology and Biotechnology*. 88(6), 992-998.

Johnson, M. B. and Wen, Z. (2009). Production of biodiesel fuel from the microalga *Schizochytrium limacinum* by direct transesterification of algal biomass. *Energy & Fuels*. 23(10), 5179-5183.

Johnson, P. (2016). Malaysia Faces Long-Term Water Crisis. News Feature. https://www.wateronline.com/doc/malaysia-faces-long-term-water-crisis-0001.

Kalesh, N. and Nair, S. (2005). The accumulation levels of heavy metals (Ni, Cr, Sr, & Ag) in marine algae from southwest coast of India. *Toxicological & Environmental Chemistry*. 87(2), 135-146.

Kamarudin, K. F., Yaakob, Z., Rajkumar, R., Takriff, M. S. and Tasirin, S. M. (2013). Bioremediation of palm oil mill effluents (POME) Using *Scenedesmus dimorphus* and *Chlorella vulgaris*. *Advanced Science Letters*. 19(10), 2914-2918.

Kamyab, H., Din, M. F. M., Tin, C. L., Ponraj, M., Soltani, M., Mohamad, S. E. and Roudi, A. M. (2014a). Micro-Macro Algal Mixture as a Promising Agent for Treating POME Discharge and its Potential Use as Animal Feed Stock Enhancer. *Jurnal Teknologi*. 68(5) 1-4.

Kamyab, H., Din, M. F. M., Keyvanfar, A., Majid, M. Z. A., Talaiekhozani, A., Shafaghat, A. and Ismail, H. H. (2015). Efficiency of microalgae *Chlamydomonas* on the removal of pollutants from palm oil mill effluent (POME). *Energy Procedia*,*75*, 2400-2408.

Kang, C. D., An, J. Y., Park, T. H. and Sim, S. J. (2006). Astaxanthin biosynthesis from simultaneous N and P uptake by the green alga *Haematococcus pluvialis* in primary-treated wastewater. *Biochemical Engineering Journal*. 31(3), 234-238.

Kavitha, S., Selvakumar, R., Sathishkumar, M., Swaminathan, K., Lakshmanaperumalsamy, P., Singh, A. and Jain, S. (2009). Nitrate removal using *Brevundimonas diminuta* MTCC 8486 from ground water. *Water Science and Technology*. 60(2), 517-524.

Kazamia, E., Czesnick, H., Nguyen, T. T. V., Croft, M. T., Sherwood, E., Sasso, S. and Smith, A. G. (2012). Mutualistic interactions between vitamin B12-dependent algae and heterotrophic bacteria exhibit regulation. *Environmental microbiology*. 14(6), 1466-1476.

Kellogg, R. L., Lander, C. H., Moffitt, D. C. and Gollehon, N. (2000). Manure nutrients relative to the capacity of cropland and pastureland to assimilate nutrients: Spatial and temporal trends for the United States. *Proceedings of the Water Environment Federation*. 2000(16), 18-157.

Kenekar, A. and Deodhar, M. (2013). Effect of Varying Physicochemical Parameters on the Productivity and Phycobiliprotein Content of Indigenous Isolate *Geitlerinema sulphureum*. *Biotechnology*. 12(3), 146-154.

Khoo, H., Sharratt, P., Das, P., Balasubramanian, R., Naraharisetti, P. and Shaik, S. (2011). Life cycle energy and $CO_2$ analysis of microalgae-to-biodiesel: preliminary results and comparisons. *Bioresource technology*. 102(10), 5800-5807.

Kim, S., Lee, Y. and Hwang, S.-J. (2013). Removal of nitrogen and phosphorus by *Chlorella sorokiniana* cultured heterotrophically in ammonia and nitrate. *International Biodeterioration & Biodegradation*. 85, 511-516.

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Kinast, J. A. (2003). Production of biodiesels from multiple feedstocks and properties of biodiesels and biodiesel/diesel blends. USA: National Renewable Energy Laboratory.

Kirkwood, A. E., Nalewajko, C. and Fulthorpe, R. R. (2001). The occurrence of cyanobacteria in pulp and paper waste-treatment systems. *Canadian journal of microbiology*. 47(8), 761-766.

Knothe, G. (2009). Improving biodiesel fuel properties by modifying fatty ester composition. *Energy & Environmental Science*. 2(7), 759-766.

Knothe, G. (2001). Historical Perspectives on Vegetable Oil-Based Diesel Fuels" (PDF). INFORM, Vol. 12(11), p. 1103-1107.

Kong, Q.-x., Li, L., Martinez, B., Chen, P. and Ruan, R. (2010). Culture of microalgae *Chlamydomonas reinhardtii* in wastewater for biomass feedstock production. *Applied biochemistry and Biotechnology*. 160(1), 9.

Kshirsagar, A. D. (2013). Bioremediation of wastewater by using microalgae: an experimental study. *International Journal of Life Sciences Biotechnology and Pharma Research*. 2(3), 339-346.

Kuenzler, E. J. (1965). Glucose-6-phosphate utilization by marine algae1. *Journal of Phycology*. 1(4), 156-164.

Kumar, P., Sharma, M. P. and Dwivedi, G. (2016). Impact of ternary blends of biodiesel on diesel engine performance. *Egyptian Journal of Petroleum*. 25(2), 255-261.

Kumar, S. D., Santhanam, P., Nandakumar, R., Anath, S., Prasath, B. B., Devi, A. S., Jeyanthi, S., Jayalakshima, T. and Ananthi, P. (2015). Preliminary study on the dye removal efficacy of immobilized marine and freshwater microalgal beads from textile wastewater. *African Journal of biotechnology*. 13(22).

Lam, M. K. and Lee, K. T. (2011). Renewable and sustainable bioenergies production from palm oil mill effluent (POME): win–win strategies toward better environmental protection. *Biotechnology Advances*. 29(1), 124-141.

Lam, M. K., Yusoff, M. I., Uemura, Y., Lim, J. W., Khoo, C. G., Lee, K. T. and Ong, H. C. (2017). Cultivation of *Chlorella vulgaris* using nutrients source from domestic wastewater for biodiesel production: Growth condition and kinetic studies. *Renewable Energy*. 103, 197-207.

Landau, S. and Everitt, B.S. (2004). A Handbook of Statistical Analyses Using SPSS, Chapman and Hall/CRC.

Lannan, E. (2011). Scale-up of algae growth system to cleanse wastewater and produce oils for biodiesel production.

Lau, P., Tam, N. and Wong, Y. (1995). Effect of algal density on nutrient removal from primary settled wastewater. *Environmental Pollution*. 89(1), 59-66.

Lee, R. E. (2008). *Phycology*. Cambridge University Press.

Lekshmi, B., Joseph, R. S., Jose, A., Abinandan, S. and Shanthakumar, S. (2015). Studies on reduction of inorganic pollutants from wastewater by *Chlorella pyrenoidosa* and *Scenedesmus abundans*. *Alexandria Engineering Journal*. 54(4), 1291-1296.

Lewis, T., Nichols, P. D. and McMeekin, T. A. (2000). Evaluation of extraction methods for recovery of fatty acids from lipid-producing microheterotrophs. *Journal of Microbiological Methods*. 43(2), 107-116.

Li, Y., Chen, Y.-F., Chen, P., Min, M., Zhou, W., Martinez, B., Zhu, J. and Ruan, R. (2011a). Characterization of a microalga *Chlorella* sp. well adapted to highly concentrated municipal wastewater for nutrient removal and biodiesel production. *Bioresource technology*. 102(8), 5138-5144.

Li, Y., Han, D., Yoon, K., Zhu, S., Sommerfeld, M. and Hu, Q. (2013b). Molecular and cellular mechanisms for lipid synthesis and accumulation in microalgae: biotechnological implications. *Handbook of Microalgal Culture*. 545-565.

Li, Y., Zhou, W., Hu, B., Min, M., Chen, P. and Ruan, R. R. (2011b). Integration of algae cultivation as biodiesel production feedstock with municipal wastewater treatment: strains screening and significance evaluation of environmental factors. *Bioresource technology*. 102(23), 10861-10867.

Lima, D. G., Soares, V. C., Ribeiro, E. B., Carvalho, D. A., Cardoso, É. C., Rassi, F. C. and Suarez, P. A. (2004). Diesel-like fuel obtained by pyrolysis of vegetable oils. *Journal of Analytical and Applied Pyrolysis*. 71(2), 987-996.

Lin, Q. and Lin, J. (2011). Effects of nitrogen source and concentration on biomass and oil production of a *Scenedesmus rubescens* like microalga. *Bioresource Technology*. 102(2), 1615-1621.

Lin, Y.-S., Liu, F.-G. R., Wang, T.-Y., Pan, C.-T., Chang, W.-T. and Li, W.-H. (2011). A simple method using PyrosequencingTM to identify de novo SNPs in pooled DNA samples. *Nucleic acids research*. 39(5), e28-e28.

Lizzul, A., Hellier, P., Purton, S., Baganz, F., Ladommatos, N. and Campos, L. (2014). Combined remediation and lipid production using *Chlorella sorokiniana* grown on wastewater and exhaust gases. *Bioresource technology*. 151, 12-18.

Luthfi, A. A. I., Manaf, S. F. A., Illias, R. M., Harun, S., Mohammad, A. W. and Jahim, J. M. (2017). Biotechnological route for sustainable succinate production utilizing oil palm frond and kenaf as potential carbon sources. *Applied microbiology and biotechnology*. 101(8), 3055-3075.

Ma, F. and Hanna, M. A. (1999). Biodiesel production: a review. *Bioresource technology*. 70(1), 1-15.

Ma, X., Zhou, W., Fu, Z., Cheng, Y., Min, M., Liu, Y., Zhang, Y., Chen, P. and Ruan, R. (2014). Effect of wastewater-borne bacteria on algal growth and nutrients removal in wastewater-based algae cultivation system. *Bioresource technology*. 167, 8-13.

Macek, T. and Mackova, M. (2011). Potential of biosorption technology *Microbial Biosorption of Metals* (pp. 7-17)Springer.

Makandar, M. B. and Bhatnagar, A. (2010). Morphotypic diversity of microalgae from arid zones of Rajasthan (India). *J. Algal Biomass Utln*. 1(2), 74-92.

Maher, K.D. and Bressler, D.C. (2007). Pyrolysis of triglyceride materials for the production of renewable fuels and chemicals. *Bioresource Technolology*. 98, pp. 2351-2368.

Mangas-Sánchez, J. and Adlercreutz, P. (2015). Highly efficient enzymatic biodiesel production promoted by particle-induced emulsification. *Biotechnology for biofuels*. 8(1), 58.

Mani, D. and Kumar, C. (2014). Biotechnological advances in bioremediation of heavy metals contaminated ecosystems: an overview with special reference to phytoremediation. *International Journal of Environmental Science and Technology*. 11(3), 843-872.

Mansouri, A., Zinatizadeh, A. and Akhbari, A. (2014). Kinetic Evaluation of Simultaneous CNP Removal in an up-Flow Aerobic/Anoxic Sludge Fixed Film (UAASFF) Bioreactor. *Iranica Journal of Energy & Environment (IJEE)*. 5(3), 323-336.

Markou, G. and Georgakakis, D. (2011). Cultivation of filamentous cyanobacteria (bluegreen) in agro-industrial wastes and wastewater: a review. *Applied Energy*. 88(10), 3389–401.

Marvá, F., López-Rodas, V., Rouco, M., Navarro, M., Toro, F. J., Costas, E. and Flores-Moya, A. (2010). Adaptation of green microalgae to the herbicides simazine and diquat as result of pre-selective mutations. *Aquatic Toxicology*. 96(2), 130-134.

Massoud, A. H., Derbalah, A. S. and Belal, E.-S. B. (2008). Microbial detoxification of metalaxyl in aquatic system. *Journal of Environmental Sciences*. 20(3), 262-267.

Mata, T. M., Melo, A. C., Simões, M. and Caetano, N. S. (2012). Parametric study of a brewery effluent treatment by microalgae *Scenedesmus obliquus*. *Bioresource technology*. 107, 151-158.

Maza-Márquez, P., Martinez-Toledo, M. V., Fenice, M., Andrade, L., Lasserrot, A. and Gonzalez-Lopez, J. (2014). Biotreatment of olive washing wastewater by a selected microalgal-bacterial consortium. *International Biodeterioration & Biodegradation*. 88, 69-76.

Meche, A., Martins, M. C., Lofrano, B. E., Hardaway, C. J., Merchant, M. and Verdade, L. (2010). Determination of heavy metals by inductively coupled plasma-optical emission spectrometry in fish from the Piracicaba River in Southern Brazil. *Microchemical Journal*. 94(2), 171-174.

Metcalf and Eddy, I. (2003). Wastewater Engineering: treatment and reuse. The McGraw Hill Companies Inc New York.

Metting, F. (1996). Biodiversity and application of microalgae. *Journal of industrial microbiology*. 17(5-6), 477-489.

Mezzomo, N., Saggiorato, A. G., Siebert, R., Tatsch, P. O., Lago, M. C., Hemkemeier, M., Costa, J. A. V., Bertolin, T. E. and Colla, L. M. (2010). Cultivation of microalgae *Spirulina platensis* (Arthrospira platensis) from biological treatment of swine wastewater. *Food Science and Technology (Campinas)*. 30(1), 173-178.

Miao, X, and Wu, Q. (2006). Biodiesel production from heterotrophic microalgal oil. *Bioresource Technology*. 97(6), 841–6.

Michels, M. H., van der Goot, A. J., Vermuë, M. H. and Wijffels, R. H. (2016). Cultivation of shear stress sensitive and tolerant microalgal species in a tubular photobioreactor equipped with a centrifugal pump. *Journal of applied phycology*. 28(1), 53-62.

Mills, D. R. and Lee, J. M. (1996). A simple, accurate method for determining wet and dry weight concentrations of plant cell suspension cultures using microcentrifuge tubes. *Plant cell reports*. 15(8), 634-636.

Mittelbach, M. (1996). Diesel fuel derived from vegetable oils, VI: Specifications and quality control of biodiesel. *Bioresource Technology*. 56(1), 7-11.

Mohan D., Pittman C.U. and Jr, P.H. (2006). SteelePyrolysis of wood/biomass for bio-oil: a critical review. *Energy Fuel.* 20, pp. 848-889.

Mohan, S. V., Devi, M. P., Mohanakrishna, G., Amarnath, N., Babu, M. L. and Sarma, P. (2011). Potential of mixed microalgae to harness biodiesel from ecological water-bodies with simultaneous treatment. *Bioresource technology*. 102(2), 1109-1117.

Mohd, P.T., NurZaida, Z. and Ibrahim Z. (2016). Effect of nutrients and inoculation of pb-tolerant bacteria on removal of pb from simulated wastewater by *Pistiastratiotes* & *Eichhorniacrassipes* Engineering Science and Technology: *An International Journal* (ESTIJ), ISSN: 2250-3498, Vol.6, No.1. www.estij.org/papers/vol6no12016/2vol6no1.pdf

Mondal, M., Khanra, S., Tiwari, O., Gayen, K. and Halder, G. (2016). Role of carbonic anhydrase on the way to biological carbon capture through microalgae—A mini review. *Environmental Progress & Sustainable Energy*. 35(6), 1605-1615.

Mujtaba, G., Rizwan, M. and Lee, K. (2015). Simultaneous removal of inorganic nutrients and organic carbon by symbiotic co-culture of Chlorella vulgaris and Pseudomonas putida. *Biotechnology and bioprocess engineering*. 20(6), 1114-1122.

Mujtaba, G., Rizwan, M. and Lee, K. (2017). Removal of nutrients and COD from wastewater using symbiotic co-culture of bacterium *Pseudomonas putida* and immobilized microalga *Chlorella vulgaris*. *Journal of Industrial and Engineering Chemistry*. 49, 145-151.

Mulbry, W., Westhead, E. K., Pizarro, C. and Sikora, L. (2005). Recycling of manure nutrients: use of algal biomass from dairy manure treatment as a slow release fertilizer. *Bioresource technology*. 96(4), 451-458.

Muniyappa, P. R., Brammer, S. C., and Noureddini, H. (1996). Improved conversion of plant oils and animal fats into biodiesel and co-product. *Bioresource Technology*. 56(1), 19-24.

Munoz, R. and Guieysse, B. (2006). Algal–bacterial processes for the treatment of hazardous contaminants: a review. *Water research*. 40(15), 2799-2815.

Mustafa, E.-M., Phang, S.-M. and Chu, W.-L. (2012). Use of an algal consortium of five algae in the treatment of landfill leachate using the high-rate algal pond system. *Journal of applied phycology*. 24(4), 953-963.

Nadkarni, R. A. and Nadkarni, R. A. (2007). *Guide to ASTM test methods for the analysis of petroleum products and lubricants*. West Conshohocken: ASTM International.

Neoh, C. H., Yahya, A., Adnan, R., Majid, Z. A. and Ibrahim, Z. (2013). Optimization of decolorization of palm oil mill effluent (POME) by growing cultures of *Aspergillus fumigatus* using response surface methodology. *Environmental Science and Pollution Research*. 20(5), 2912-2923.

Nyrén, P. (2015). The History of Pyrosequencing®. *Pyrosequencing: Methods and Protocols*. 3-15.

Olguí, E. J. (2003). Phycoremediation: key issues for cost-effective nutrient removal processes. *Biotechnology advances*. 22(1), 81-91.

Omidvarborna, H., Kumar, A. and Kim, D.-S. (2014). Characterization of particulate matter emitted from transit buses fueled with B20 in idle modes. *Journal of Environmental Chemical Engineering*. 2(4), 2335-2342.

Onalo, J. I., Peralta, H. M. M. and Sunar, N. M. (2014). Growth of freshwater microalga, *Botryococcus* sp. in heavy metal contaminated industrial wastewater. *Journal of Science and Technology*. 6(2).

Osundeko, O., Davies, H. and Pittman, J. K. (2013). Oxidative stress-tolerant microalgae strains are highly efficient for biofuel feedstock production on wastewater. *Biomass and bioenergy*. 56, 284-294.

Osundeko, O., Dean, A. P., Davies, H. and Pittman, J. K. (2014). Acclimation of microalgae to wastewater environments involves increased oxidative stress tolerance activity. *Plant and Cell Physiology*. 55(10), 1848-1857.

Oswald, W. J. (1988). Large-scale algal culture systems (engineering aspects). *Micro-algal biotechnology. Cambridge University Press, Cambridge*. 357-394.

Painter, T. J. (1993). Carbohydrate polymers in desert reclamation: the potential of microalgal biofertilizers. *Carbohydrate polymers*. 20(2), 77-86.

Pandey, P. and Shi, J. (2017). Assessing nutrient removal kinetics in flushed manure using *Chlorella vulgaris* biomass production. *Frontiers in bioengineering and biotechnology*. 5.

Pankaj, V. P. and Awasthi, M. (2015). "Characterization of indigenous microalgae." International Journal of Scientific & Engineering Research. 6(3), 434-434.

Pantos, O., Bongaerts, P., Dennis, P. G., Tyson, G. W. and Hoegh-Guldberg, O. (2015). Habitat-specific environmental conditions primarily control the microbiomes of the coral Seriatopora hystrix. *The ISME journal*. 9(9), 1916-1927.

Patil, K., Mahajan, R. T. (2014). Enzymatic study of freshwater macro and micro algae isolated from jalgaon, Maharashtra. *International Journal of Pharmacy and Bio Sciences*. 7(1), 207-215.

Perez-Garcia, O. and Bashan, Y. (2015). Microalgal heterotrophic and mixotrophic culturing for bio-refining: From metabolic routes to techno-economics. In *Algal biorefineries* (pp. 61-131). Springer International Publishing.

Perrineau, M. M., Zelzion, E., Gross, J., Price, D. C., Boyd, J. and Bhattacharya, D. (2014). Evolution of salt tolerance in a laboratory reared population of *Chlamydomonas reinhardtii*. *Environmental microbiology*. 16(6), 1755-1766.

Pienkos, P. T. and Darzins, A. L. (2009). The promise and challenges of microalgal-derived biofuels. *Biofuels, Bioproducts and Biorefining*. 3(4), 431-440.

Pittman, J. K., Dean, A. P. and Osundeko, O. (2011). The potential of sustainable algal biofuel production using wastewater resources. *Bioresource technology*. 102(1), 17-25.

Pooja, K., Sreekanth, D., Banu, S. S. and Himabindu, V. (2014). Treatment of Dairy Wastewater Using Microalgae *Botryococcus braunii* for Simultaneous Lipid Production. *HYDROLOGY AND WATERSHED MANAGEMENT: Ecosystem Resilience-Rural and Urban Water Requirements*. 1, 372.

Raghavendra P. S.A. (2014). A Review on CNSL Biodiesel as an Alternative fuel for Diesel Engine. *International Journal of Science and Research* 3 (7), 2028-2038.

Rahman, M. A., Reichman, S. M., De Filippis, L., Sany, S. B. T. and Hasegawa, H. (2016). Phytoremediation of Toxic Metals in Soils and Wetlands: Concepts and Applications *Environmental Remediation Technologies for Metal-Contaminated Soils* (pp. 161-195)Springer.

Ramanna, L., Guldhe, A., Rawat, I. and Bux, F. (2014). The optimization of biomass and lipid yields of *Chlorella sorokiniana* when using wastewater supplemented with different nitrogen sources. *Bioresource technology*. 168, 127-135.

Ramanan, R., Kim, B. H., Cho, D. H., Oh, H. M. and Kim, H. S. (2016). Algae–bacteria interactions: evolution, ecology and emerging applications. *Biotechnology advances*. 34(1), 14-29.

Ramírez-Verduzco, L. F., Rodríguez-Rodríguez, J. E. and del Rayo Jaramillo-Jacob, A. (2012). Predicting cetane number, kinematic viscosity, density and higher heating value of biodiesel from its fatty acid methyl ester composition. *Fuel*. 91(1), 102-111.

Ramírez-Mérida, L.G., Zepka, L.Q. and Jacob-Lopes, E. (2015). Why does the Photobioreactors Fail? *Journal of Bioprocessing and Biotechniques.* 5:7.

Raut, N., Al-Balushi, T., Panwar, S., Vaidya, R. S. and Shinde, G. B. (2015). Microalgal Biofuel. In *Biofuels-Status and Perspective*. InTech. http://dx.doi.org/10.5772/59821.

Rawat, I., Kumar, R. R., Mutanda, T. and Bux, F. (2011). Dual role of microalgae: phycoremediation of domestic wastewater and biomass production for sustainable biofuels production. *Applied Energy*. 88(10), 3411-3424.

Renuka, N., Sood, A., Prasanna, R. and Ahluwalia, A. S. (2014). Influence of seasonal variation in water quality on the microalgal diversity of sewage wastewater. *South African Journal of Botany*. 90, 137-145.

Rezania, B., Cicek, N. and Oleszkiewicz, J. (2005). Kinetics of hydrogen-dependent denitrification under varying pH and temperature conditions. *Biotechnology and bioengineering*. 92(7), 900-906.

Richmond, A. and Hu, Q. (2013). *Handbook of microalgal culture: applied phycology and biotechnology*. John Wiley & Sons.

Rodolfi, L., Chini Zittelli, G., Bassi, N., Padovani, G., Biondi, N., Bonini, G. and Tredici, M. R. (2009). Microalgae for oil: Strain selection, induction of lipid synthesis and outdoor mass cultivation in a low-cost photobioreactor. *Biotechnology and bioengineering*. 102(1), 100-112.

Rohlich, G. (1969). Eutrophication: causes, consequences, correctives. *Proceedings of the 1969 Proceedings of a Symposium National Academy of Sciences, Washington, DC. ISBN*, 309-301.

Ronaghi, M. (2001). Pyrosequencing sheds light on DNA sequencing. *Genome research*. 11(1), 3-11.

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*. 11(1), 70-81.

Ryckebosch, E., Bruneel, C., Termote-Verhalle, R., Goiris, K., Muylaert, K. and Foubert, I. (2014). Nutritional evaluation of microalgae oils rich in omega-3 long chain polyunsaturated fatty acids as an alternative for fish oil. *Food Chemistry*. 160, 393–400.

Sahay, S. and Braganza, V. J. (2016). Microalgae based biodiesel production–current and future scenario. *Journal of Experimental Sciences*. 7, 31-35.

Sahu, O. (2014). Reduction of organic and inorganic pollutant from waste water by algae. *International Letters of Natural Sciences*. 8(1).

Saidu, H., Jamaluddin H., Iwamoto K., Yahya A. and Mohamad S.V. (2017). Low-cost biodiesel production. *Asian Journal of Applied Science*. 10(2): 57-65. DOI; DOI: 10.3923/ajaps.2017.

Saifuddin, N., and Dinara, S. (2011). Pretreatment of palm oil mill effluent (POME) using magnetic chitosan. *Journal of Chemistry*. 8(S1), S67-S78.

Sapari, N., Idris, A. and Hamid, N. H. A. (1996). Total removal of heavy metal from mixed plating rinse wastewater. *Desalination*. 106(1), 419-422.

Saunders, R. J., Paul, N. A., Hu, Y. and De Nys, R. (2012). Sustainable sources of biomass for bioremediation of heavy metals in waste water derived from coal-fired power generation. *PloS one*. 7(5), e36470.

Sawayama, S., Minowa, T., Dote, Y. and Yokoyama, S. (1992). Growth of the hydrocarbon-rich microalga *Botryococcus braunii* in secondarily treated sewage. *Applied microbiology and biotechnology*. 38(1), 135-138.

Selvam, T. B., Renganathan, R. and Takriff, M. S. (2015). Nutrient Removal of POME using POME isolated microalgae strain, *Characium* sp. *Advanced Materials Research*. 1113.

Sen, B., Sonmez, F., Kocer, M. A. T., Alp, M. T. and Canpolat, O. (2013). *Relationship of algae to water pollution and waste water treatment*. INTECH Open Access Publisher.

Sheehan, J., Dunahay, T., Benemann, J., and Roessler, P. (1998). Look back at the US department of energy's aquatic species program: biodiesel from algae; close-out report (No. NREL/TP-580-24190). *National Renewable Energy Lab., Golden*, CO.(US).

Sialve, B., Bernet, N. and Bernard, O. (2009). Anaerobic digestion of microalgae as a necessary step to make microalgal biodiesel sustainable. *Biotechnology Advances*. 27, 409– 416.

Silitonga, A. S., Ong, H. C., Mahlia, T. M. I., Masjuki, H. H. and Chong, W. T. (2013). Characterization and production of *Ceiba pentandra* biodiesel and its blends. *Fuel*. 108, 855-858.

Singh, U. B. and Ahluwalia, A. (2013). Microalgae: a promising tool for carbon sequestration. *Mitigation and Adaptation Strategies for Global Change*. 18(1), 73-95.

Singh, V., Tiwari, A. and Das, M. (2016). Phyco-remediation of industrial waste-water and flue gases with algal-diesel engenderment from micro-algae: a review. *Fuel*. 173, 90-97.

Stříteský, L., Pešoutová, R. and Hlavínek, P. (2015). Malt house wastewater treatment with settleable algal-bacterial flocs. *Water Science and Technology*. 72(10), 1796-1802.

Sturm, B. S. and Lamer, S. L. (2011). An energy evaluation of coupling nutrient removal from wastewater with algal biomass production. *Applied Energy*. 88(10), 3499-3506.

Su, Y., Mennerich, A. and Urban, B. (2012a). Coupled nutrient removal and biomass production with mixed algal culture: impact of biotic and abiotic factors. *Bioresource technology*. 118, 469-476.

Su, Y., Mennerich, A. and Urban, B. (2012b). Synergistic cooperation between wastewater-born algae and activated sludge for wastewater treatment: influence of algae and sludge inoculation ratios. *Bioresource technology*. 105, 67-73.

Tan, X., Chu, H., Zhang, Y., Yang, L., Zhao, F. and Zhou, X. (2014). *Chlorella pyrenoidosa* cultivation using anaerobic digested starch processing wastewater in an airlift circulation photobioreactor. *Bioresource technology*. 170, 538-548.

Teo, C. L., Jamaluddin, H., Zain, N. A. M. and Idris, A. (2014). Biodiesel production via lipase catalysed transesterification of microalgae lipids from Tetraselmis sp. *Renewable Energy*. 68, 1-5.

Teresa, L. Alleman, Robert, L. and McCormick, (2016). Biodiesel handling and use guide (Fifth Edition). U.S department of energy. National Renewable Energy Laboratory.

Tredici, M.R. (2010). Photobiology of microalgae mass cultures: understanding the tools for the next green revolution. Biofuels.1, 143–62.

Tyx, R. E., Stanfill, S. B., Keong, L. M., Rivera, A. J., Satten, G. A. and Watson, C. H. (2016). Characterization of bacterial communities in selected smokeless tobacco products using 16S rDNA analysis. *PloS one*. 11(1), e0146939.

Vairappan, C. S. and Yen, A. M. (2008). Palm oil mill effluent (POME) cultured marine microalgae as supplementary diet for rotifer culture. *Journal of applied phycology*. 20(5), 603-608.

Vandamme, D., Foubert, I. and Muylaert, K. (2013). Flocculation as a low-cost method for harvesting microalgae for bulk biomass production. *Trends in biotechnology*. 31(4), 233-239.

Varshney, P., Sohoni, S., Wangikar, P. P. and Beardall, J. (2016). Effect of high $CO_2$ concentrations on the growth and macromolecular composition of a heat-and high-light-tolerant microalga. *Journal of Applied Phycology*. 28(5), 2631-2640.

Vijayakumar, S., Thajuddin, N. and Manoharan, C. (2007). Biodiversity of cyanobacteria in industrial effluents. *Press*

Wang, J.-H., Zhang, T.-Y., Dao, G.-H., Xu, X.-Q., Wang, X.-X. and Hu, H.-Y. (2017). Microalgae-based advanced municipal wastewater treatment for reuse in water bodies. *Applied microbiology and biotechnology*. 101(7), 2659-2675.

Wang, L., Li, Y., Chen, P., Min, M., Chen, Y., Zhu, J. and Ruan, R. R. (2010a). Anaerobic digested dairy manure as a nutrient supplement for cultivation of oil-rich green microalgae *Chlorella* sp. *Bioresource technology*. 101(8), 2623-2628.

Wang, L., Min, M., Li, Y., Chen, P., Chen, Y., Liu, Y., Wang, Y. and Ruan, R. (2010b). Cultivation of green algae *Chlorella* sp. in different wastewaters from municipal wastewater treatment plant. *Applied biochemistry and biotechnology*. 162(4), 1174-1186.

Wang, X., Broch, O. J., Forbord, S., Handå, A., Skjermo, J., Reitan, K. I., Vadstein, O. and Olsen, Y. (2014). Assimilation of inorganic nutrients from salmon (Salmo salar) farming by the macroalgae (*Saccharina latissima*) in an exposed coastal environment: implications for integrated multi-trophic aquaculture. *Journal of applied phycology*. 26(4), 1869-1878.

Wang, X. and Zhao, H. (2013). Isolation and Characterization of a *Bacillus flexus* Strain Used in Alkaline Wastewater Treatment. *Proceedings of the 2013 Advanced Materials Research*: Trans Tech Publ, 1381-1384.

Weller, K. (2014). *Environmental science and biological engineering*. (Vol. 156)WIT Press.

Wen, D., Jiang, H. and Zhang, K. (2009). Supercritical fluids technology for clean biofuel production. *Progress in Natural science*. 19(3), 273-284.

Westermeier, R. (2016). Electrophoresis in practice: a guide to methods and applications of DNA and protein separations. John Wiley & Sons.

Widjaja, A. (2009). Lipid production from microalgae as a promising candidate for biodiesel production. *Makara Teknologi*. 13(1), 47-51.

Wijanarko, A. (2011). Effect of the Presence of Substituted Urea and Also Ammonia as Nitrogen Source in Cultivied Medium on *Chlorella* Lipid Content. INTECH Open Access Publisher.

Wilde, E. W. and Benemann, J. R. (1993). Bioremoval of heavy metals by the use of microalgae. *Biotechnology Advances*. 11(4), 781-812.

Williams, P.J.L.B. and Laurens, L.M.L. (2010). Microalgae as biodiesel and biomass feedstocks: review and analysis of the biochemistry, energetics and economics. *Energy Environ Sci*. 3, 554–90.

Woertz, I., Feffer, A., Lundquist, T. and Nelson, Y. (2009). Algae grown on dairy and municipal wastewater for simultaneous nutrient removal and lipid production for biofuel feedstock. *Journal of Environmental Engineering*. 135(11), 1115-1122.

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(7), 1467-1490.

Yaakob, Z., Ali, E., Zainal, A., Mohamad, M. and Takriff, M.S. (2014). An overview: biomolecules from microalgae for animal feed and aquaculture. *Journal of Biological ResearchThessaloniki*. 21:6.

Yadavalli, R. and Heggers, G. R. V. N. (2013). Two stage treatment of dairy effluent using immobilized *Chlorella pyrenoidosa*. *Journal of Environmental Health Science and Engineering*. 11(1), 36.

Yang, X.-e., Wu, X., Hao, H.-l. and He, Z.-l. (2008). Mechanisms and assessment of water eutrophication. *Journal of Zhejiang University Science B*. 9(3), 197-209.

Yu, Q., Matheickal, J. T., Yin, P. and Kaewsarn, P. (1999). Heavy metal uptake capacities of common marine macro algal biomass. *Water research*. 33(6), 1534-1537.

Yuan, X., Kumar, A., Sahu, A. K. and Ergas, S. J. (2011). Impact of ammonia concentration on *Spirulina platensis* growth in an airlift photobioreactor. *Bioresource technology*. 102(3), 3234-3239.

Zhang, H.-L., Fang, W., Wang, Y.-P., Sheng, G.-P., Zeng, R. J., Li, W.-W. and Yu, H.-Q. (2013). Phosphorus removal in an enhanced biological phosphorus removal process: roles of extracellular polymeric substances. *Environmental science & technology*. 47(20), 11482-11489.

Zhang, Y., Su, H., Zhong, Y., Zhang, C., Shen, Z., Sang, W., Yan, G. and Zhou, X. (2012). The effect of bacterial contamination on the heterotrophic cultivation of *Chlorella pyrenoidosa* in wastewater from the production of soybean products. *Water research*. 46(17), 5509-5516.

Zhou, W., Chen, P., Min, M., Ma, X., Wang, J., Griffith, R., Hussain, F., Peng, P., Xie, Q. and Li, Y. (2014). Environment-enhancing algal biofuel production using wastewaters. *Renewable and sustainable energy reviews*. 36, 256-269.

Zhou, W., Hu, B., Li, Y., Min, M., Mohr, M., Du, Z., Chen, P. and Ruan, R. (2012a). Mass cultivation of microalgae on animal wastewater: a sequential two-stage cultivation process for energy crop and omega-3-rich animal feed production. *Applied biochemistry and biotechnology*. 168(2), 348-363.

Zhou, W., Li, Y., Min, M., Hu, B., Zhang, H., Ma, X., Li, L., Cheng, Y., Chen, P. and Ruan, R. (2012b). Growing wastewater-born microalga *Auxenochlorella protothecoides* UMN280 on concentrated municipal wastewater for simultaneous nutrient removal and energy feedstock production. *Applied Energy*. 98, 433-440.

Zhou, W. and Qiu, B. (2004). Mechanisms for heavy metal detoxification and tolerance in algae. *Journal of Lake Sciences.* 16(3), 264-272.

Zhu, L., Wang, Z., Takala, J., Hiltunen, E., Qin, L., Xu, Z., Qin, X. and Yuan, Z. (2013). Scale-up potential of cultivating *Chlorella zofingiensis* in piggery wastewater for biodiesel production. *Bioresource technology*. 137, 318-325.