PHYCOREMEDIATION OF ARTIFICIAL BATHROOM GREYWATER IN VILLAGE HOUSES USING MICROALGAE *Botryococcus* sp.

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DEDICATION

I dedicate this work to my beloved son Ahmed Rayyan and my darling wife Hauwa Atiku.

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ABSTRACT

The sources of water pollution in Malaysia are domestic sewage and industrial waste. Direct discharge of household bathroom greywater into drains cause euthrophication into the water bodies. Phycoremediation of bathroom greywater effluent to meet a certain level of discharge limit using microalgae *Botryococcus* sp. is suggested. The objectives of this study is to asses quality of nutrients in raw bathroom greywater, produce artificial bathroom greywater (ABGW) recipe with Response Surface Methodology, to study biokinetic absorption of microalgae through phycoremediation. To optimize *Botryococcus* sp. cell concentration, pH and the efficiency of laboratory scale treatment system with *Botryococcus* sp. was observed. The first objective results shown that NO_3-N and PO_4-P were 1.03-7.54 & 0.12-22.7 mg/L respectively and 63 L/c/day was discharged to drains as raw bathroom greywater. Secondly, ABGW recipe for soap, detergent, shampoo, shower gel, toothpaste were 0.13, 0.97, 0.88, 0.34, 0.37 mg/L respectively and pH= 6.55. The optimum concentration of *Botryococcus* sp. was 10^6 cells/mL and pH 7 for the third objective. Fourthly, the efficiency of *Botryococcus* sp. in removing NO_3-N was 97% and PO_4-P 87% in ABGW on the 30th day of phycoremediation, while biokinetic absorption rate using Michaelis-Menten coefficient were K =0.46 mgNO_3-N mg/*chl* a/day & K_m =12.501 mg/L (R^2 = 0.83) and PO_4-P coefficients were K =8.53 mgPO_4-P mg/*chl* a/day & K_m =176.88 mg/L (R^2 = 0.94). Lastly, the efficiency of *Botryococcus* sp. in laboratory scale treatment system was 90.98% and 93.88% for NO_3-N while 80.9% and 83% for PO_4-P on the 13th day of phycoremediation in ABGW and raw bathroom greywater respectively. Statistically, algal days of culture, growth of algae, pH, temperature and light correlated well ($p<0.05$ & 0.01) influencing high nutrient removal in the system. Therefore, this proves that *Botryococcus* sp. has high potential to absorb NO_3-N and PO_4-P from household bathroom greywater. Hence, the system of this study represents an effective solution for remediation of bathroom greywater.

ABSTRAK

Sumber-sumber pencemaran air di Malaysia adalah sisa kumbahan domestik dan sisa industri. Pelepasan langsung air sisa dari bilik air rumah kediaman ke dalam longkang menyebabkan berlakunya euthrophikasi ke dalam saliran air semulajadi. Penggunaan mikroalga *Botryococcus* sp. bagi pykoremediasi air sisa dari bilik mandi bagi memenuhi tahap tertentu had pelepasan adalah dicadangkan. Objektif kajian ini adalah untuk menilai kualiti nutrien dalam air sisa dari bilik mandi, menghasilkan resepi air sisa dari bilik mandi buatan (ABGW) dengan Kaedah *Response Surface*, untuk mengkaji penyerapan *biokinetic* mikroalga melalui pykoremediasi. Bagi mengoptimumkan kepekatan sel *Botryococcus* sp., pH dan kecekapan sistem rawatan skala makmal dengan *Botryococcus* sp. diperhatikan. Bagi objektif pertama, kajian menunjukkan bahawa NO_3-N dan PO_4-P bagi air sisa bilik mandi masing-masing mempunyai nilai 1.03-7.54 & 0.12-22.7 mg/L dan 63 L/c/ hari telah dilepaskan ke longkang. Kedua, resipi ABGW untuk sabun, bahan pencuci, syampu, gel mandian, ubat gigi masing-masing adalah 0.13, 0.97, 0.88, 0.34, 0.37 mg/L dan pH = 6.55. Kepekatan optimum *Botryococcus* sp. adalah 10^6 sel / mL dan pH 7 untuk objektif ketiga. Keempat, kecekapan *Botryococcus* sp. dalam menghapuskan NO_3-N adalah 97% dan PO_4-P 87% pada ABGW pada hari ke-30 pykoremediasi, manakala kadar penyerapan *biokinetic* menggunakan pekali Michaelis-Menten adalah K = 0.46 mgNO_3-N mg/*chl a*/hari & K_m = 12.501 mg/L (R^2 = 0.83) dan PO_4-P pekali adalah K = 8.53 mgPO_4-P mg/chl a/hari & K_m = 176.88 mg/L (R^2 = 0.94). Akhir sekali, kecekapan *Botryococcus* sp. dalam sistem rawatan skala makmal bagi NO_3-N adalah 90.98% dan 93.88% manakala 80.9% dan 83% untuk PO_4-P pada hari ke-13 dalam pykoredemiasi ABGW dan air sisa dari bilik mandi yang belum diproses. Secara statistik, hari pembiakan alga, kadart pertumbuhan alga, pH, suhu dan cahaya mempunyai kaitan yang baik ($p <0.05$ & 0.01) mempengaruhi penyingkiran nutrien yang tinggi di dalam sistem. Oleh itu, ini membuktikan bahawa *Botryococcus* sp. mempunyai potensi yang tinggi untuk menyerap NO_3-N dan PO_4-P dari air sisa dari bilik air rumah kediaman. Oleh itu, sistem kajian ini merupakan penyelesaian yang berkesan untuk pemulihan air sisa mandian.

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LIST OF ABBREVIATIONS

BOD	-	Biochemical Oxygen Demand
COD	-	Chemical Oxygen Demand
TSS	-	Total Suspended Solids
NH_4^+	-	Ammonium
NO_3^-	-	Nitrate
NO_3-N	-	Nitrate-N
PO_4-P	-	Phosphate-P
OP_4^{3-}	-	Orthophosphate
CO_2	-	Carbondioxide
DHA	-	Docosahexaenoic Acid
GHG	-	Green House Gases
Mg	-	Magnesium
Ca	-	Calcium
TN	-	Total Nitrogen
N	-	Nitrogen
P	-	Phosphorus
TP	-	Total Phosphorus
DNA	-	Dioxoribonucleic Acid
RNA	-	Ribonucleic Acid
ABGW	-	Artificial Bathroom Greywater
ATP	-	Adesonine triphosphate
RSM	-	Response Surface Methodology
PDDA	-	Polyelectrolyte polydiallyldimethyl Ammonium Chloride
DAF	-	Dissolved Air Flotation
CTAB	-	Cationic N-cetyl-N-N-N trimethyl Ammonium
NaCl	-	Sodium Chloride
UTHM	-	Universiti Tun Hussein Onn Malaysia

APHA	-	American public health association
CCD	-	Central Composite Design
SMBR	-	Submerged membrane bioreactor
FSTPI	-	Fakulti Sains, Teknology dan Pembangunan Insan

LIST OF PUBLICATIONS

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Hauwa Atiku Majidda, Radin Maya Saphira Radin Mohamed, Al-Gheethi AA, **Anwaruddin Ahmed Wurochekke** & Amir Hashim Mohd Kassim. 2016. Harvesting Microalgae Biomass from the Phycoremediation Process of Greywater. *Environmental Science and Pollution Research*, 23(16) (ISI, IF= 2.8, Q1).

Anwaruddin Ahmed Wurochekke, Radin Maya Saphira Radin Mohamed, Siti Asmah Binti Lokman Halim, Amir Hashim bin Mohd. Kassim and Rafidah Binti Hamdan. 2015. Sustainable Extensive On-Site Constructed Wetland for Some Bacteriological Reduction in Kitchen Greywater. In *Applied Mechanics and Materials* (773), 1199-1204) (Scopus).

Anwaruddin Ahmed Wurochekke, Radin Maya Saphira Radin Mohamed, Chee-Ming Chan and Amir Hashim bin Mohd. Kassim. 2014. The Use of Natural Filter Media Added with Peat Soil for Household Greywater Treatment. *International Journal of Engineering Technology* (JET) 2(4).

Radin Maya Saphira Radin Mohamed, **Anwaruddin Ahmed Wurochekke**, Siti Solehah Mohd Hadzri and Amir Hashim Mohd Kassim. 2015. Induction Performance of pn-Site Low Cost Treatment Unit for Treating Kitchen Greywater at Village House. *Journal of Applied Sciences Research* 11(10), 22-28.

Anwaruddin Ahmed Wurochekke, Nurul Azma Harun, Radin Maya Saphira Radin Mohamed and Amir Hashim Bin Mohd. Kassim, (2014). Constructed Wetland of *Lepironia Articulata* for Household Greywater Treatment presented at the INTERNATIONAL CONFERENCE ON ENVIRONMENTAL SCIENCE AND DEVELOPEMENT Singapore, 20th February, 2014.

Radin Maya Saphira binti Radin Mohamed, **Anwaruddin Ahmed Wurochekke**, Siti Solehah binti Mohd Hadzri, Sabariah Musa and Amir Hashim bin Mohd. Kassim, (2014). Preliminary Performance of On-Site Low Cost Treatment Unit for Treating Kitchen Greywater At Village House presented at the NATIONAL SEMINAR ON CIVIL ENGINEERING RESEARCH SEPKA, Johor, 14th April, 2014.

Anwaruddin Ahmed Wurochekke, Radin Maya Saphira Radin Mohamed, Hauwa Atiku, Suriani Sharuddin and Amir Hashim Mohd. Kassim. Improvement of Bathroom Greywater Quality after Phycoremediation with Microalgae *Botryococcus* sp. presented at the INTERNATIONAL CONFERENCE ON ENVIRONMENTAL FORENSICS (iENFORCE 2015), 19-20, August 2015.

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Al-Gheethi AA, Mohamed RMSR, **Wurochekke AA**, Nurulainee NR, Mas Rahayu J, Amir Hashim MK. Efficiency of *Moringa oleifera* seeds for Treatment of Laundry Wastewater presented at the INTERNATIONAL SYMPOSIUM ON CIVIL AND ENVIRONMENTAL ENGINEERING (ISCEE 2016), 25-26 October, 2016.

CHAPTER 1

INTRODUCTION

1.1 Background

The speedy growth of the human population and their activities have caused serious water pollution and insufficient freshwater in many developing countries. It is a driving force for everybody to think of alternatives and sustainable solutions to manage this valuable resource (Qu *et al*., 2013). In Jordan, water scarcity occurred due to the growing population over the previous decade. The availability per capita of water decreased to 198 m^3/capita/year from the standard of 1000 m^3/capita/year from 1996 to 2013 (Boufaroua *et al*., 2013; Najib Al-Beiruti, 2005) which has affected the economic growth in Jordan. The high cost of usual sewers is one of the main restraints to expand wastewater services to small communities. As a result, domestic wastewater especially from greywater sources goes uncollected contributing phosphorus, nitrogen and other elements into water bodies. However, Jordanian water management has implemented some models to change how water is handled and appreciated due to the present water plan from the ministry of water and irrigation which is responsible for the management of operations, maintenance cost and supply, treating and distribution (Al-Beiruti, 2007). Hence, these would increase greywater reuse and reduce the amount of pollutants being discharged into water bodies.

In India, about 25 billion liters of untreated wastewater are discharged into the water bodies daily (Parjane & Sane, 2011). This untreated wastewater will lead to health problems and increase infectious diseases such as diarrhea, dysentery, skin and tissue infections (Akpor *et al*., 2011). Furthermore, in India, the International Water Management Institute (IWMI) forecast that by 2025 one person in three will facetotal water shortage. Similarly, rapid development and industrialization in Malaysia have affected water resources especially in the rural community. Besides, the decrease in quality of water in many rivers has mainly contributed to the water problem in Malaysia. The rivers of Kuantan and Belat were monitored by Kozaki *et al*., (2016) and it was found that the pollution level of some ions were as follows: 4.44-14.9 for NH_4^+, 3.71-18.1 for NO_3^-,154-6429 for Na^+ and 33.8-1363 for Mg^{2+} respectively. These pollutants were influenced by human activities like the discharge of untreated water from human sewage and household waste, and also industrial point sources. Thus, they are becoming serious issues and need to be solved before worsening.

Greywater is another alternative source to substitute freshwater usage but it contains contaminants (Parjane & Sane, 2011). Greywater is a type of wastewater derived from the kitchen, bathroom (i.e. discharge from the hand basin, shower, and bath) and also laundry water. Bathroom contributes more than 50% of the total usable greywater volume in a typical household (Donner *et al*., 2010; Coghlan & Higgs, 2003). Besides that, greywater which originates from bathrooms and showers make up over 30 per cent of household greywater flow (Edwin *et al*., 2014). Water used for washing hands and showers generate about 50-60% of the total greywater and it can be considered as least polluted type of greywater compared to others. Common chemical pollutants include soap, shampoo, hair dye, toothpaste and cleaning products. It also has a number of faecal contaminations 3.2 x 10^5 CFU/100mL through body wash (Saumya *et al*., 2015).

However, greywater does not include the wastewater that is generated from toilet use which is normally considered as black water. However, greywater is generated in different quantities between household to household within one community and depends on different factors such as lifestyle and household activities (Al-Mashaqbeh *et al*., 2012). Many communities in Malaysia, mainly villagers, dispose bathroom greywater directly into the nearest ditch. These inputs promote eutrophication in water bodies and naturally there will be a decline in water quality. At the same time, the removal of nutrients and organic compounds from greywater is an essential means to avert eutrophication and water bloom. Therefore, bathroom greywater ought to obtain proper treatment prior to being discharged into water bodies.

Numerous systems operate for the removal of nutrients from greywater, although these are expensive and generate elevated thick soft mud (Ruiz-Marin *et al*., 2010). Natural treatment systems via primary settling with cascaded water flow, aeration, agitation and filtration (Parjane & Sane, 2011; Pangarkar *et al*., 2010) were used and are less expensive. Yet, there is lack of information when it concerns the removal of nutrients especially phycoremediation with microalgae *Botryococcus* sp. Greywater management treatment system is a system that allows direct utilization of the water. It can use the natural gravity by a hybrid treatment process with the use of natural materials and wetland system. It will facilitate in breaking down the organic compounds and recovery of nutrients (Parjane & Sane, 2011). Bathroom greywater should preferably be treated anaerobically because of lower treatment costs and the possibility of recovering energy (Leal *et al*., 2010).

Therefore, in this study phycoremediation with microalgae *Botryococcus* sp. as a laboratory scale system will be adopted. Based on the aforementioned criteria, greywater treatment options for households will be advocated. Since uptake is the major means of removing nutrients by microalgae, the colony of microalgal growth squarely influences the nutrient removal rate. Greywater can contain nutrients such as total phosphorus (TP), total nitrogen (TN) from detergents (Maya *et al*., 2013b; Park *et al*., 2011b) and total organic carbon (TOC) (Beck *et al*., 2013b; Li *et al*., 2009) that benefit algal growth. Therefore, the usage of microalgae for treatment was proposed for a simple greywater treatment system especially for greywater from the bathroom source.

1.2 Problem Statement

Conventional discharge of greywater into drains gains the least attention in terms of environmental sanitation such as toilet waste and solid waste disposals. In individual village house areas in Malaysia, bathroom greywater is most often discharged untreated into storm water drains. These discharge can cause unpleasant odours, bread mosquitos, flies, aesthetic of the environment is disturb and add nutrients (nitrogen and phosphorus) in the drain. Excess nutrients in bathroom greywater causes eutrophication. This discharge of untreated bathroom greywater in an uncontrolled manner to the main drain with excess nutrients flow in to the rivers. Rivers are the main source of water supply in Malaysia. Therefore, eutrophication of rivers with enrich nutrients rapidly grow algae. The decaying algae plant reduce dissolved oxygen, fish and other aquatic life die. In addition, the rapid increase of pollutants (nutrients and pathogens) will occur actively and result in an unhealthy environment for humans or animals with dangerous diseases. Bathroom greywater effluents have high concentrations of nitrogen and phosphorus content which are normally generated by activities such as bathing. It is anticipated that the utmost source of nitrogen is urine, as some people pass urine in the shower rooms or from body washing and bathing through the use of protein-rich shampoos and conditioners. Additionally, nutrient loads may come from washing babies, children after defecation, diaper changes or diaper washing. Phosphorus is mainly found in detergents. Therefore, bathroom greywater treatment is necessary before discharging the treated greywater to water bodies.

1.3 Aim of study

The aim of this study is to evaluate the efficiency of phycoremediation in treating bathroom greywater from village households. This study intends to ascertain the potential for treated bathroom greywater to reduce pollutant loads of nearby water bodies.

1.4 Objective of study

This study embarks on the following objectives:

1. To assess the nutrient, elements availability and the quality and quantity of bathroom greywater from selected case study houses.
2. To optimize bathroom products for the production of an artificial bathroom greywater (ABGW) recipe.

3. To optimize *Botryococcus* sp. cell concentration for best growth and pH of ABGW.
4. To determine ABGW nutrient removal efficiency and mechanism on biokinetic absorption rate.
5. To determine the efficiency of Laboratory Scale Greywater Treatment System for nutrient (nitrate-N and phosphate-P) removal and influence of environmental factors during phycoremediation of ABGW and raw bathroom greywater in a photobioreactor using *Botryococcus* sp.

1.5 Scope of Study

The scope of this study includes the isolation of a microalgae called *Botryococcus* sp. at the microbiology laboratory, Fakulti Sains, Teknology dan Pembangunan Insan (FSTPi), Universiti Tun Hussein Onn Malaysia (UTHM). This microalgae was originally obtained from the Endau Rompin forest reserve in Johor, Malaysia.

Household activities were ascertained using interviews and a questionnaire in four households around Parit Raja. Bathroom greywater loading was measured during the composite sampling by comparing the production of bathroom greywater in the mornings and in the night. Water quality parameters were tested for pH, BOD_5, COD, TSS, Turbidity, ammonium, nitrate-N, phosphate-P, Ca, Na and Mg to assess the quality of bathroom greywater collected. The artificial bathroom greywater recipe was produced using domestic products. Phycoremediation was done on bathroom greywater with *Botryococcus* sp. to determine its efficiency on nutrient removal (nitrate-N and phosphate-P) and chloropyll-a content. The adsorption rate of *Botryococcus* sp. on nitrate-N and phosphate-P were determined with a biokinetic model of Michaealis-Menten equation $\frac{1}{R_{xi}} = \frac{1}{K} + \frac{K_m}{K}\frac{1}{S_o}$ and environmental factors like light, temperature and pH on algal growth were observed during phycoremediation.

The Laboratory Scale Greywater Treatment System (photobioreactor) was built to represent the phycoremediation efficiency of ABGW and raw bathroom greywater for

REFERENCES

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

Abedin, S., & Rakib, Z. (2013). Generation and Quality Analysis of Greywater at Dhaka City. *Environmental Research, Engineering and Management, 2*(64), 29–41.

Abou-Shanab, R. A. I., Ji, M.-K., Kim, H.-C., Paeng, K.-J., & 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.

Adamsson, M., Dave, G., Forsberg, L., & Guterstam, B. (1998). Toxicity identification evaluation of ammonia, nitrite and heavy metals at the Stensund Wastewater Aquaculture plant, Sweden. *Water Science and Technology*, *38*(3), 151–157.

Akpor, O. B., Muchie, M. (2011). Environmental and public health implications of wastewater quality. *African Journal of Biotechnology*, *10*(13), 2379–2387.

Al-Beiruti, S. N. (2007). *INWRDAM Experience in Greywater Treatment and Use in Jordan and Nearby Countries*. Jordan.

Al-Hamaiedeh, H., & Bino, M. (2010). Effect of treated grey water reuse in irrigation on soil and plants. *Desalination*, *256*(1–3), 115–119.

Al-Jayyousi, O. R. (2003). Greywater reuse: Towards sustainable water management. *Desalination*, *156*(1–3), 181–192.

Al-Mashaqbeh, O. a., Ghrair, A. M., & Megdal, S. B. (2012). Grey Water Reuse for Agricultural Purposes in the Jordan Valley: Household Survey Results in Deir Alla. *Water*, *4*(4), 580–596.

Alderlieste, M., Baumeyer, A., Bino, M. J., Burnat, J., Dallas, S., Hind, M., … Figures, S. (2006). *Greywater Management in Low and Middle-Income Countries, Review of different treatment systems for households or neighbourhoods*. Switzerland.

Allen, L., Christian-Smith, J., & Palaniappan, M. (2010). *Overview of greywater* *reuse: The potential of greywater systems to aid sustainable water management*. California.

Altschul, S. F., Madden, T. L., Schäffer, A. A., Zhang, J., Zhang, Z., Miller, W., & Lipman, D. J. (1997). Gapped BLAST and PSI-BLAST:a new generation of protein database search programs. *Nucleic Acids Res*, *25*(17), 3389–3402.

Amin, M. Al, & Mahmud, K. (2011). Domestic water consumption patterns in a village in Bangladesh. In *4th Annual Paper Meet and 1st Civil Engineering Congress* (pp. 83–85). Dhaka, Bangladesh: Chowdhury and Kakoli.

An, J. Y., Sim, S. J., Lee, J. S., & Kim, B. W. (2003). Hydrocarbon production from secondarily treated piggery wastewater by the green alga Botryococcus braunii. *Journal of Applied Phycology*, *15*(2–3), 185–191.

Antonopoulou, G., Kirkou, A., & Stasinakis, A. S. (2013). Quantitative and qualitative greywater characterization in Greek households and investigation of their treatment using physicochemical methods. *Science of the Total Environment*, *454–455*, 426–432.

APHA. (2012). *Standard Methods for the Examination of Water and Wastewater* (22nd editi). Washington, DC.: American Public Health Association(APHA), American Water Works Association (AWWA), Water Environment Federation (WEF).

Areco, M. M., Cainzos, V., & Curutchet, G. (2013). Copper Removal by Botryococcus braunii Biomass with Associated Production of Hydrocarbons. *Advanced Materials Research*, *825*(2015), 528–531.

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

Assayed, A. K., Dalahmeh, S. S., & Suleiman, W. T. (2010). Onsite Greywater Treatment Using Septic Tank Followed by Intermittent Sand Filter- A Case Study of Abu Al Farth Village in Jordan. *International Journal of Chemical and Environmental Engineering*, *1*(1), 67–71.

Atiku, H., & Maya Saphira Radin Mohamed, R. (2016). Bathroom Greywater Bioremediation by Microalgae Botryococcus sp. *Indian Journal of Science and Technology*, *9*(46).

Bajhaiya, A. K., Mandotra, S. K., Suseela, M. R., Toppo, K., & Ranade, S. (2010). Review Article Algal Biodiesel: The next generation biofuel for India. *Asian.J.Exp.Biol.Sci.*, *1*(4), 728–739.

Beck, S. E., Rodríguez, R. a., Salveson, A., Goel, N., Rhodes, S., Kehoe, P., & Linden, K. G. (2013a). Disinfection Methods for Treating Low TOC, Light Graywater to California Title 22 Water Reuse Standards. *Journal of Environmental Engineering*, *139*(9), 1137–1145.

Beck, S. E., Rodríguez, R. A., Salveson, A., Goel, N., Rhodes, S., Kehoe, P., & Linden, K. G. (2013b). Disinfection Methods for Treating Low TOC, Light Graywater to California Title 22 Water Reuse Standards. *Journal of Environmental Engineering*, *139*(9), 1137–1145.

Bird, S. C., & Drizo, A. (2010). EAF Steel Slag Filters for Phosphorus Removal from Milk Parlor Effluent: The Effects of Solids Loading, Alternate Feeding Regimes and In-Series Design. *Water*, *2*(3), 484–499.

Birungi, Z. S., & Chirwa, E. M. N. (2014). The kinetics of uptake and recovery of lanthanum using freshwater algae as biosorbents: Comparative analysis. *Bioresource Technology*, *160*, 43–51.

Bishoff, H. W., & Bold, H. C. (1963). *Phycological Studies IV. Some algae from enchanted rock and related algae species*. Texas: Univ. Texas Publ, (6318).

Bitton, G. (2011). *Wastewater Microbiology*. *Wastewater Microbiology* (4th Editio). Hoboken, New Jersey: John Wiley & Sons, Inc.

Borowitzka, M. A. (1999). Commercial production of microalgae: ponds, tanks, tubes and fermenters. *Journal of Biotechnology*, *70*(1–3), 313–321.

Boufaroua, M., Albalawneh, A., & Oweis, T. (2013). Assessing the Efficiency of Grey-Water Reuse at Household Level and Its Suitability for Sustainable Rural and Human Development, *3*(4), 962–972.

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

Cardoso, M., & Antunes, M. (2016). Greywater treatment using a moving bed bio fi lm reactor at a university campus in Brazil. *Journal of Cleaner Production*, *142*(1), 290–296.

Carpenter, S. R. (2008). Phosphorus control is critical to mitigating eutrophication. *The National Academy of Sciences of the USA*, *105*(32), 11039–11040.

Ceron Garcia, M. C., Fernandez Sevilla, J. M., Acien Fernandez, F. G., Molina Grima, E., & Garcia Camacho, F. (2000). Mixotrophic growth of Phaeodactylum tricornutum on glycerol : growth rate and fatty acid profile. *Journal of Applied*

Phycology 12:, *12*, 239–248.

Chaillou, K., Gérente, C., Andrès, Y., & Wolbert, D. (2011). Bathroom Greywater Characterization and Potential Treatments for Reuse. *Water Air Soil Pollut*, *215*(1), 31–42.

Cheng, B., Zhu, N., Fan, R., Zhou, C., Zhang, G., Li, W., & Ji, K. (2002). Computer aided optimum design of rubber recipe using uniform design. *Polymer Testing*, *21*(1), 83–88.

Chevalier, P., Proulx, D., Lessard, P., Vincent, W. F., & De La Noüe, J. (2000). Nitrogen and phosphorus removal by high latitude mat-forming cyanobacteria for potential use in tertiary wastewater treatment. *Journal of Applied Phycology*, *12*(2), 105–112.

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

Chisti, Y. (2008). Biodiesel from microalgae beats bioethanol. *Trends in Biotechnology*, *26*(3), 126–131.

Christenson, L., & Sims, R. (2011). Production and harvesting of microalgae for wastewater treatment, biofuels, and bioproducts. *Biotechnology Advances*, *29*(6), 686–702.

Christova-Boal, D., Eden, R. E., & McFarlane, S. (1996). Investigation into greywater reuse for urban residential properties. *Desalination*, *106*(1–3), 391–397.

Chu, W. (2012). Biotechnological applications of microalgae. *International E-Journal of Science, Medicine & Education*, *6*(126), 24–37.

Coghlan, P., & Higgs, C. (2003). *Domestic Water Use Study. In Perth, Western Australia 1998-2001. Hydro 2000: Interactive Hydrology*. Perth.

Coleman, A., Suarez, A., & Goff, L. (1994). Molecular delineation of species and syngens in volvocacean green algae (Chlorophyta). *Journal of Phycology*.

Converti, A., Casazza, A. A., Ortiz, E. Y., Perego, P., & Del Borghi, M. (2009). Effect of temperature and nitrogen concentration on the growth and lipid content of Nannochloropsis oculata and Chlorella vulgaris for biodiesel production. *Chemical Engineering and Processing: Process Intensification*, *48*(6), 1146–1151.

Cuellar-Bermudez, S. P., Garcia-Perez, J. S., Rittmann, B. E., & Parra-Saldivar, R. (2015). Photosynthetic bioenergy utilizing CO_2: An approach on flue gases utilization for third generation biofuels. *Journal of Cleaner Production*, *98*, 53–65.

Cullings, K. W. (1992). Design and testing of a plant-specific PCR primer for ecological and evolutionary studies. *Molecular Ecology*, *1*(4), 233–240.

Dalahmeh, S. S., Jönsson, H., Hylander, L. D., Hui, N., Yu, D., & Pell, M. (2014). Dynamics and functions of bacterial communities in bark, charcoal and sand filters treating greywater. *Water Research*, *54*, 21–32.

Dalahmeh, S. S., Pell, M., Vinnerås, B., Hylander, L. D., Öborn, I., & Jönsson, H. (2012). Efficiency of Bark, Activated Charcoal, Foam and Sand Filters in Reducing Pollutants from Greywater. *Water, Air, & Soil Pollution*, *223*(7), 3657–3671.

Dayananda, C., Sarada, R., Rani, M. U., Shamala, T. R., & Ravishankar, G. A. (2007). Autotrophic cultivation of Botryococcus braunii for the production of hydrocarbons and exopolysaccharides in various media. *Biomass and Bioenergy 31*, *31*(1), 87–93.

Diaper, C., Toifl, M., & Storey, M. (2008). *Greywater Technology Testing Protocol*. Australia.

Dixit, S., & Singh, D. P. (2013). Phycoremediation of lead and cadmium by employing Nostoc muscorum as biosorbent and optimization of its biosorption potential. *International Journal of Phytoremediation*, *15*(8), 801–813.

Donner, E., Eriksson, E., Revitt, D. M., Scholes, L., L??tzh??ft, H. C. H., & Ledin, A. (2010). Presence and fate of priority substances in domestic greywater treatment and reuse systems. *Science of the Total Environment*, *408*(12), 2444–2451.

Edwin, G. a., Gopalsamy, P., & Muthu, N. (2014). Characterization of domestic gray water from point source to determine the potential for urban residential reuse: a short review. *Applied Water Science*, *4*(1), 39–49.

Eriksson, E. Ã., & Donner, E. (2009). Metals in greywater : Sources , presence and removal efficiencies. *Desalination*, *248*(1–3), 271–278.

Eriksson, E., Auffarth, K., Eilersen, A. M., Henze, M., & Ledin, A. (2003). Household chemicals and personal care products as sources for xenobiotic organic compounds in grey wastewater. *Water SA*, *29*(2), 135–146.

Eriksson, E., Auffarth, K., Henze, M., & Ledin, A. (2002). Characteristics of grey wastewater. *Urban Water*, *4*(1), 85–104.

Farooq, W., Moon, M., Ryu, B. gon, Suh, W. I., Shrivastav, A., Park, M. S., Yang, J.

W. (2015). Effect of harvesting methods on the reusability of water for cultivation of chlorella vulgaris, its lipid productivity and biodiesel quality. *Algal Research*, *8*, 1–7.

Fernandes, B., Teixeira, J., Dragone, G., Vicente, A. A., Kawano, S., Bisova, K., Vitova, M. (2013). Relationship between starch and lipid accumulation induced by nutrient depletion and replenishment in the microalga Parachlorella kessleri. *Bioresource Technology*, *144*, 268–274.

Ferrero, E. M., de Godos, I., Rodriguez, E. M., Garcia-Encina, P. A., Munoz, R., & Becares, E. (2012). Molecular characterization of bacterial communities in algal-bacterial photobioreactors treating piggery wastewaters. *Ecological Engineering*, *40*, 121–130.

Fiksen, Ø., Follows, M. J., & Aksnes, D. L. (2013). Trait-based models of nutrient uptake in microbes extend the Michaelis- Menten framework. *Limnol Oceanog*, *58*(1), 193–202.

Fountoulakis, M. S., Markakis, N., Petousi, I., & Manios, T. (2016). Single house on-site grey water treatment using a submerged membrane bioreactor for toilet flushing. *Science of the Total Environment*, *551–552*, 706–711.

Gani, P., Sunar, N. M., Latiff, a a, Kamaludin, N. S., Parjo, U. K., Emparan, Q., & Er, C. M. (2015). Experimental Study for Phycoremediation of Botryococcus sp . On Greywater. *Applied Mechanics and Materials*, *773–774*(2015), 1312–1317.

García, J., Green, B. F., Lundquist, T., Mujeriego, R., Hernández-Mariné, M., & Oswald, W. J. (2006). Long term diurnal variations in contaminant removal in high rate ponds treating urban wastewater. *Bioresource Technology*, *97*(14), 1709–1715.

Gera, G., Yewalkar, S. N., & Nene, S. N. (2015). *Algal Biorefinery: An Integrated Approach* (D. Das (ed). India: Capital Publishing Company.

Gerardi, M. H. (2006). *Wastewater Bacteria*. (M. H. Gerardi, Ed.) (1st edt.). Hoboken, New Jersey: John Wiley & Sons, Inc.

Gokulan, R., Sathish, N., & Praveen Kumar, R. (2013). Treatment of grey water using hydrocarbon producing Botryococcus braunii. *International Journal of ChemTech Research*, *5*(3), 1390–1392.

Goldman, J. C., Dennett, M. R., & Riley, C. B. (1982). Effect of nitrogen-mediated changes in alkalinity on pH control and CO(2) supply in intensive microalgal cultures. *Biotechnology and Bioengineering*, *24*(3), 619–631.

Gonz, O., Gonz, S., & Tel, D. F. (2008). Distribution of heterotrophic and autotrophic organisms in a biological aerated filter. *Water Practice &Technology*, *3*(3), 1–10.

Granato, D., Castro, I. A. DE, Ellendersen, L. S. N., & Luciamasson, M. (2010). Physical Stability Assessment and Sensory Optimization of a Dairy-Free Emulsion Using Response Surface Methodology. *Journal of Food Science*, *75*(3), 149–155.

Gross, A., Shmueli, O., Ronen, Z., & Raveh, E. (2007). Recycled vertical flow constructed wetland (RVFCW)-a novel method of recycling greywater for irrigation in small communities and households. *Chemosphere*, *66*(5), 916–923.

Gunes, K., Tuncsiper, B., Ayaz, S., & Drizo, A. (2012). The ability of free water surface constructed wetland system to treat high strength domestic wastewater: A case study for the Mediterranean. *Ecological Engineering*, *44*, 278–284.

Harju, V. (2010). *Assembling and Testing of Laboratory Scale Greywater Treatment System*. Tampere University of Applied Science.

Harun, R., Singh, M., Forde, G. M., & Danquah, M. K. (2010). Bioprocess engineering of microalgae to produce a variety of consumer products. *Renewable and Sustainable Energy Reviews*, *14*(3), 1037–1047.

Hasegawa, H., & Masahiko, I. (1994). Variation in Michaelis-Menten Kinetic Parameters for Nitrate by the Young Seedlings in Rice (Oryza sativa L.). *Breeding Science*, *44*, 383–386.

Hernández Leal, L., Temmink, H., Zeeman, G., & Buisman, C. J. N. (2011). Characterization and anaerobic biodegradability of grey water. *Desalination*, *270*(1–3), 111–115.

Ho, S. H., Chen, C. Y., & Chang, J. S. (2012). Effect of light intensity and nitrogen starvation on CO_2 fixation and lipid/carbohydrate production of an indigenous microalga Scenedesmus obliquus CNW-N. *Bioresource Technology*, *113*, 244–252.

Hourlier, F., Masse, A., Jaouen, P., Lakel, A., Gerente, C., Faur, C., & Cloirec, P. Le. (2010). Formulation of synthetic greywater as an evaluation tool for wastewater recycling technologies. *Environmental*, *31*(2), 37–41.

Hu, Q., Sommerfeld, M., Jarvis, E., Ghirardi, M., Posewitz, M., Seibert, M., & Darzins, A. (2008). Microalgal triacylglycerols as feedstocks for biofuel production: Perspectives and advances. *Plant Journal*, *54*(4), 621–639.

Huang, Z., Ong, S. L., & Y., N. H. (2011). Submerged anaerobic membrane bioreactor for low-strength wastewater treatment: Effect of HRT and SRT on treatment performance and membrane fouling. *Water Research*, *45*(2), 705–713.

Hyde, K. (2013). An evaluation of the theoretical potential and practical opportunity for using recycled greywater for domestic purposes in Ghana. *Journal of Cleaner Production*, *60*, 195–200.

Jamrah, A., & Ayyash, S. (2008). Greywater Generation and Characterization in Major Cities in Jordan. *Jordan Journal of Civil Engineering*, *2*(4), 376–390.

Janssen, M., Kuijpers, T. C., Veldhoen, B., Ternbach, M. B., Tramper, J., Mur, L. R., & Wijffels, R. H. (1999). Specific growth rate of Chlamydomonas reinhardtii and Chlorella sorokiniana under medium duration light/dark cycles: 13-87 s. *Journal of Biotechnology*, *70*(1–3), 323–333.

Janssen, P. J. D., Lambreva, M. D., Plumeré, N., Bartolucci, C., Antonacci, A., Buonasera, K., Rea, G. (2014). Photosynthesis at the forefront of a sustainable life. *Frontiers in Chemistry*, *2*(36), 1–22.

Jefferson, B., Palmer, A., Jeffrey, P., Stuetz, R., & Judd, S. (2004). Jefferson_WST. *Water Science and Technology*, *50*(2), 157–164.

Jeffrey, P., & Jefferson, B. (2003). Public receptiviy regarding in-house water recycling: results from a UK survey. *Water Science & Technology-Water Supply*, *3*(3), 109–116.

Jiménez-pérez, M. V, Sánchez-castillo, P., & Romera, O. (2004). Growth and nutrient removal in free and immobilized planktonic green algae isolated from pig manure. *Enzyme and Microbial Technology*, *34*(5), 392–398.

Johnson, D. S. (2012). *Genome-Wide Mapping of in Vivo*. *Science* (316). Washington, DC.

Juneja, A., Ceballos, R. M., & Murthy, G. S. (2013). Effects of environmental factors and nutrient availability on the biochemical composition of algae for biofuels production: A review. *Energies*, *6*(9), 4607–4638.

Kariuki, F. W., Kotut, K., & Ngángá, V. G. (2011). The Potential of a Low Cost Technology for The Greywater Treatment. *The Open Environmental Engineering Journal*, *4*, 32–39.

Karlsson, S. C., Dalahmeh, S., Lalander, C., & Jönsson, H. (2013). Hydraulic Properties and Reduction of COD , Phosphorus and Nitrogen in a Sand Filter used for Greywater Treatment – Simulation and Verification. *4th International Conference*, 1–8.

Karthikeyan, P., Manimaran, K., Sampathkumar, P., & Rameshkumar, L. (2013). Growth and nutrient removal properties of the diatoms, Chaetoceros curvisetus and C. simplex under different nitrogen sources. *Applied Water Science*, *3*(1), 49–55.

Kim, M. K., Park, J. W., Park, C. S., Kim, S. J., Jeune, K. H., Chang, M. U., & Acreman, J. (2007). Enhanced production of Scenedesmus spp. (green microalgae) using a new medium containing fermented swine wastewater. *Bioresource Technology*, *98*(11), 2220–2228.

Klausmeier, C. A., Litchman, E., Daufresne, T., & Levin, S. A. (2004). Optimal nitrogen-to-phosphorus stoichiometry of phytoplankton. *Nature*, *429*(6988), 171–174.

Komarek, J., & Marvan, P. (1992). Morphological Differences in Natural Populations of the Genus Botryococcus (Chlorophyceae). *Arch. Protistenkd*, *141*(1–2), 65–100.

Konopka, A., Brock, T. D., & Konopkat, A. (1978). Effect of temperature on blue-green algae (Cyanobacteria) in lake effect of temperature on blue-g reen Algae (Cyanobacteria) in Lake Mendota. *Applied and Environmental Microbiology*, *36*(4), 572–576.

Kozaki, D., Hasbi, M., Mohd, W., Ishak, W., Yusoff, M. M., Mori, M., Tanaka, K. (2016). Assessment of the River Water Pollution Levels in Kuantan , Malaysia , Using Ion-Exclusion Chromatographic Data , Water Quality Indices , and Land Usage Patterns. *Air, Soil and Water Research*, *9*, 1–11.

Kuenzler, E. (1965). Glucose-6-Phopsphate Utilization by Marine Algae. *Journal of Phycology*, *31*(17), 156–64.

Kumar, K. S., Dahms, H., Won, E., Lee, J., & Shin, K. (2015). Ecotoxicology and Environmental Safety Microalgae – A promising tool for heavy metal remediation. *Ecotoxicology and Environmental Safety*, *113*, 329–352.

Lai, C. Y., Groth, A., Gray, S., & Duke, M. (2014). Preparation and characterization of poly(vinylidene fluoride)/nanoclay nanocomposite flat sheet membranes for abrasion resistance. *Water Research*, *57*, 56–66.

Lalander, C., Dalahmeh, S., Jönsson, H., & Vinnerås, B. (2013). Hygienic quality of artificial greywater subjected to aerobic treatment: a comparison of three filter media at increasing organic loading rates. *Environmental Technology*, *34*(17–20), 2657–62.

Lau, P. S., Tam, N. F. Y., & Wong, Y. S. (1998). Operational Optimization of Batchwise Nutrient Removal from Wastewater by Carrageenan Immobilized Chlorella Vulgaris. *Water Science and Technology*, *38*(1), 185–192.

Leal, L. H., Temmink, H., Zeeman, G., & Buisman, C. J. N. (2010). Comparison of Three Systems for Biological Greywater Treatment. *Water*, *2*(2), 155–169.

Lee, K., & Lee, C. (2001). Effect of Light / dark Cycles on Wastewater Treatments by Microalgae Cell Growth under Different Light Conditions. *Biotechnol. Bioprocess Eng.*, *6*(3), 194–199.

Li, C., Yang, H., Xia, X., Li, Y., Chen, L., Zhang, M., Wang, W. (2013). High efficient treatment of citric acid effluent by Chlorella vulgaris and potential biomass utilization. *Bioresource Technology*, *127*, 248–255.

Li, F., Wichmann, K., & Otterpohl, R. (2009). Evaluation of appropriate technologies for grey water treatments and reuses. *Water Science and Technology*, *59*(2), 249–260.

Libhaber, M., & Jaramillo, A. O. (2012). *Sustainable Treatment and Reuse of Municipal Wastewater* (1th ed.). London: IWApublishing.

Liu, C., Huang, X., Wang, X., Zhang, X., & Li, G. (2006). Phylogenetic studies on two strains of Antarctic ice algae based on morphological and molecular characteristics. *Phycologia*, *45*(2), 190–198.

Liu, H., Zhu, M., Gao, S., Xia, S., & Sun, L. (2014). Enhancing denitrification phosphorus removal with a novel nutrient removal process : Role of configuration. *Chemical Engineering Journal*, *240*, 404–412.

Liu, Y. X., Yang, T. O., Yuan, D. X., & Wu, X. Y. (2010). Study of municipal wastewater treatment with oyster shell as biological aerated filter medium. *Desalination*, *254*(1–3), 149–153.

Luo, H., Huang, G., Fu, X., Liu, X., Zheng, D., Peng, J., Sun, X. (2013). Waste oyster shell as a kind of active filler to treat the combined wastewater at an estuary. *Journal of Environmental Sciences (China)*, *25*(10), 2047–2055.

Maimon, A., Tal, A., Friedler, E., & Gross, A. (2010). Safe on-Site Reuse of Greywater for Irrigation-A Critical Review of Current Guidelines. *Environmental Science & Technology*, *44*(9), 3213–3220.

Mara, D., & Kramer, A. (2008). The 2006 WHO guidelines for wastewater and greywater use in agriculture: a practical interpretation. In *In Efficient Management of Wastewater* (pp. 1–17). Berling: Springer Berlin Heidelberg.

Martínez, M. (2000). Nitrogen and phosphorus removal from urban wastewater by the microalga Scenedesmus obliquus. *Bioresource Technology*, *73*(3), 263–272.

Martínez, M. E., Jiménez, J. M., & El Yousfi, F. (1999). Influence of phosphorus concentration and temperature on growth and phosphorus uptake by the microalga Scenedesmus obliquus. *Bioresource Technology*, *67*(3), 233–240.

Mata, T. M., Martins, A. A., & Caetano, N. S. (2010). Microalgae for biodiesel production and other applications: A review. *Renewable and Sustainable Energy Reviews*, *14*(1), 217–232.

Maya, R., & Radin, S. (2016). Multi-Component filters for domestic graywater treatment in Village houses. *Journal - American Water Works Association*, *108*(7), 405–415.

Maya, R., Radin, S., Solehah, S., Hadzri, M., Hashim, A., & Kassim, M. (2015). Induction Performance of pn-Site Low Cost Treatment Unit for Treating Kitchen Greywater at Village House. *Journal of Applied Sciences Research*, *11*(10), 22–28.

Mayo, A. W., & Mutamba, J. (2005). Modelling nitrogen removal in a coupled HRP and unplanted horizontal flow subsurface gravel bed constructed wetland. *Physics and Chemistry of the Earth*, *30*(11), 673–679.

Medlin, L., Elwood, H. J., Stickel, S., & Sogin, M. L. (1988). The characterization of enzymatically amplified eukaryotic 16S-like rRNA-coding regions. *Gene*, *71*(2), 491–499.

Melo-Guimarães, A., Torner-Morales, F. J., Durán-Álvarez, J. C., & Jiménez-Cisneros, B. E. (2013). Removal and fate of emerging contaminants combining biological, flocculation and membrane treatments. *Water Science & Technology*, *67*(4), 877–885.

Merz, C., Scheumann, R., El Hamouri, B., & Kraume, M. (2007). Membrane bioreactor technology for the treatment of greywater from a sports and leisure club. *Desalination*, *215*(1–3), 37–43.

Metcalf, & Eddy. (2004). *Wastewater Engineering Treatment and Reuse*. (G. Tchobanoglous, F. L. Burton, & H. D. Stensel, Eds.) (Fourth Edi). McGraw Hill Companies, Inc.

Mofokeng, B. N. M. (2008). *The Greywater Situation in Informal Settlements of The Ekurhuleni Metropolitan Municipality - Eastern Region (Gauteng , South Africa)*. North West University,South Africa.

Mohamed, N. M., & Ali, S. S. (2012). Economic study for greywater reuse to achieve the sustainability in Egypt. *Australian Journal of Basic and Applied Sciences*, *6*(3), 655–665.

Mohamed, R. M. S. R., Chan, C.-M., Ghani, H. B., & Yasin, M. A. b. M. (2013b). Application of Peat Filter Media in Treating Kitchen Wastewater. *International Journal of Zero Waste Generation*, *1*(1), 11–16.

Mohamed, R. M. S. R., Chan, C. M., Senin, H., & Kassim, A. H. M. (2014b). Feasibility of the direct filtration over peat filter media for bathroom greywater treatment. *Journal of Materials and Environmental Science*, *5*(6), 2021–2029.

Mohamed, R. M. S. R., Kassim, A. H. M., Anda, M., & Dallas, S. (2013a). A monitoring of environmental effects from household greywater reuse for garden irrigation. *Environmental Monitoring and Assessment*, *185*(10), 8473–8488.

Mohamed, R. M. S. R., Chan, C.-M., & Kassim, A. H. bin M. (2014a). The Use of Natural Filter Media Added with Peat Soil for Household Greywater Treatment. *International Journal of Engineering Technology*, *2*(3), 14–20.

Munir, N., Imtiaz, A., Sharif, N., & Naz, S. (2015). Optimization of growth conditions of different algal strains and determination of their lipid contents. *Journal of Animal and Plant Sciences*, *25*(2), 546–553.

Muñoz, R., & Guieysse, B. (2006). Algal-bacterial processes for the treatment of hazardous contaminants: A review. *Water Research*, *40*(15), 2799–2815.

Nacorda, J. O., Martinez-Goss, M. R., Torreta, N. K., & Merca, F. E. (2007). Metal resistance and removal by two strains of the green alga, Chlorella vulgaris Beijerinck, isolated from Laguna de Bay, Philippines. *Journal of Applied Phycology*, *19*(6), 701–710.

Najib Al-Beiruti, S. (2005). No Title. In *In Potential of greywater treatment and reuse in Jordan: exchange of know-how between Islamic countries*. UNESCO.

Nakajima, J., Fujimura, Y., & Inamori, Y. (1999). Performance evaluation of on-site treatment facilities for wastewater from households, hotels and restaurants. *Water Science and Technology*, *39*(8), 85–92.

N S W, G. (2007). *Greywater Reuse in Sewered, Single Household Residential Premises*. Sydney.

Niwagaba, C. B., Dinno, P., Wamala, I., Dalahmeh, S. S., Lalander, C., & Jönsson, H. (2014). Experiences on the implementation of a pilot grey water treatment and reuse based system at a household in the slum of Kyebando-Kisalosalo, Kampala.

Journal of Water Reuse and Desalination, *4*(4), 294–307.

Nnaji, C. C., Mama, C. N., Ekwueme, A., & Utsev, T. (2013a). Feasibility of a Filtration-Adsorption Grey Water Treatment System for Developing Countries. *Hydrology Current Research*, *s1*(1), 1–6.

Nnaji, C. C., Mama, C. N., Ekwueme, A., & Utsev, T. (2013b). Feasibility of a Filtration-Adsorption Grey Water Treatment System for Developing Countries. *Journal of Waste Water Treatment & Analysis*, *1*(1), 1–6.

Noie, J. De, Lalibert, G., & Proulx, D. (1992). Algae and waste water. *Journal of Applied Phycology*, *4*(1), 247–254.

Nurdogan, Y. (1988). *Microalgal separation from high-rate ponds*. Univ. of California, United States.

Olguin, E. J., & Sanchez-Galvan, G. (2003). Phycoremediation: Key issues for cost-effective nutrient removal processes. *Biotechnology Advances*, *22*(1–2), 81–91.

Oliver, R. L., & Ganf, G. G. (2000). *Freshwater blooms In: The ecology of cyanobactria, their diversity in time and space*. (B. Whitton & M. Potts, Eds.) (eds). United kingdom: Kluwer Academic publishers.

Oron, G., Adel, M., Agmon, V., Friedler, E., Halperin, R., Leshem, E., & Weinberg, D. (2014). Greywater use in Israel and worldwide: standards and prospects. *Water Research*, *58*, 92–101.

Orpez, R., Martnez, M. E., Hodaifa, G., El Yousfi, F., Jbari, N., & S??nchez, S. (2009). Growth of the microalga Botryococcus braunii in secondarily treated sewage. *Desalination*, *246*(1–3), 625–630.

Oswald, W. J. (1995). Ponds in The Twenty-First Century. *Water Science and Technology*, *31*(12), 1–8.

Pangarkar, B. L., Parjane, S. B., & Sane, M. G. (2010). Design and Economical Performance of Gray Water Treatment Plant in Rural Region. *International Journal of Environmental Science and Engineering*, *2*(1), 1–5.

Parjane, S. B., & Sane, M. G. (2011). Performance of grey water treatment plant by economical way for Indian rural development, *3*(4), 1808–1815.

Park, J. B. K., Craggs, R. J., & Shilton, A. N. (2010). Wastewater treatment high rate algal ponds for biofuel production. *Bioresource Technology*, *102*(1), 35–42.

Park, W. H. (2009). Integrated constructed wetland systems employing alum sludge and oyster shells as filter media for P removal. *Ecological Engineering*, *35*(8), 1275–1282.

Parlevliet, D., & Moheimani, N. R. (2014). Efficient conversion of solar energy to biomass and electricity. *Aquatic Biosystems*, *10*(4), 1–9.

Patrick, C. N., & Ebere, M. (2014). Optimization of Chemical Treatment Conditions for Adenia Lobata Fiber Using CCD. *International Journal of engineering and innovative Technology*, *4*(6), 23–32.

Ponnuswamy, I., Madhavan, S., & Shabudeen, S. (2013). Isolation and Characterization green microalgae for Carbon Sequestration Waste water treatment and bio-fuel production. *International Journal of Bio-Science and Bio-Technology*, *5*(2), 17–26.

Powell, N., Shilton, A., Chisti, Y., & Pratt, S. (2009). Towards a luxury uptake process via microalgae – Defining the polyphosphate dynamics. *Water Research*, *43*(17), 4207–4213.

Poyyamoli, G., Edwin, G. A., & Muthu, N. (2013). Constructed Wetlands for the Treatment of Domestic Grey Water : An Instrument of the Green Economy to Realize the Millennium Development Goals. In Simpson, Richard, Zimmermann, & Monika (Eds.), *In The Economy of Green Cities* ((Eds.), pp. 313–321). Netherlands.

Prathapar, S. A., Jamrah, A., Ahmed, M., Adawi, S. Al, Sidairi, S. Al, & Harassi, A. Al. (2005). Overcoming constraints in treated greywater reuse in Oman. *Desalination*, *186*(1–3), 177–186.

Qu, X., Alvarez, P. J. J., & Li, Q. (2013). Applications of nanotechnology in water and wastewater treatment. *Water Research*, *47*(12), 3931–3946.

Rao, L. N., & Pradesh, A. (2011). Removal of Heavy Metals By Biosorption – an Overall Review. *Journal of Engineering Research and Studies*, *2*(4), 17–22.

Rao, P. H., Kumar, R. R., Raghavan, B. G., Subramanian, V. V, & Sivasubramanian, V. (2011). Application of phycoremediation technology in the treatment of wastewater from a leather-processing chemical manufacturing facility. *Water SA*, *37*(1), 7–14.

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

Rawat, I., Ranjith Kumar, R., Mutanda, T., & Bux, F. (2013). Biodiesel from microalgae: A critical evaluation from laboratory to large scale production. *Applied Energy*, *103*(C), 444–467.

Ruiz-Marin, A., Mendoza-Espinosa, L. G., & Stephenson, T. (2010). Growth and nutrient removal in free and immobilized green algae in batch and semi-continuous cultures treating real wastewater. *Bioresource Technology*, *101*(1), 58–64.

Ruiz-martinez, A., Garcia, N. M., Romero, I., Seco, A., & Ferrer, J. (2012). Bioresource Technology Microalgae cultivation in wastewater : Nutrient removal from anaerobic membrane bioreactor effluent. *Bioresource Technology*, *126*(1), 247–253.

Saumya, S., Akansha, S., Rinaldo, J., Jayasri, M. A., & Suthindhiran, K. (2015). Construction and evaluation of prototype subsurface flow wetland planted with Heliconia angusta for the treatment of synthetic greywater. *Journal of Cleaner Production*, *91*, 235–240.

Schalkwyk, A. Van. (1996). *Report to the Water Research Commission: guidelines for the estimation of domestic water demand of developing communities in the Northern Transvaal*. South Africa.

Shaban, A., & Sharma, R. N. (2007, June). Water Consumption Patterns in Domestic Households in Major Cities. *Economic and Political Weekly*, *42*(23), 2190–2197.

Sharma, Y. C., Singh, B., & Upadhyay, S. N. (2008). Advancements in development and characterization of biodiesel: A review. *Fuel*, *87*(12), 2355–2373.

Shi, J., Podola, B., & Melkonian, M. (2007). Removal of nitrogen and phosphorus from wastewater using microalgae immobilized on twin layers: An experimental study. *Journal of Applied Phycology*, *19*(5), 417–423.

Singh, O., & Turkiya, S. (2013). A survey of household domestic water consumption patterns in rural semi-arid village, India. *GeoJournal*, *78*(5), 777–790.

Singh, R. N., & Sharma, S. (2012). Development of suitable photobioreactor for algae production – A review. *Renewable and Sustainable Energy Reviews*, *16*(4), 2347–2353.

Singh, S. P., & Singh, P. (2015). Effect of temperature and light on the growth of algae species: A review. *Renewable and Sustainable Energy Reviews*, *50*(1), 431–444.

Singh, V., Tiwari, A., & Das, M. (2016). Phyco-remediation of industrial waste-water and flue gases with algal-diesel engenderment from micro-algae : A review. *Fuel*, *173*(1), 90–97.

Siracusa, G., & La Rosa, A. D. (2006). Design of a constructed wetland for wastewater treatment in a Sicilian town and environmental evaluation using the emergy analysis. *Ecological Modelling*, *197*(3–4), 490–497.

Spolaore, P., Joannis-Cassan, C., Duran, E., & Isambert, A. (2006). Commercial applications of microalgae. *Journal of Bioscience and Bioengineering*, *101*(2), 87–96.

Sriram, S., & Seenivasan, R. (2012). Microalgae Cultivation in Wastewater for Nutrient Removal. *Journal of Algal Biomass Utilization*, *3*(2), 9–13.

Stanley, E. M. (2001). *fundamentals of analytical chemistry in fundamentals of environmental chemistry*. Boca Raton, USA: CRC Press LLC.

Stringfellow, W. T., Borglin, S. E., & Hanlon, J. S. (2006). *Measurement and Modeling of Algal Biokinetics in Highly Eutrophic Waters*. Berkeley.

Teh, X. Y., Poh, P. E., Gouwanda, D., & Chong, M. N. (2015). Decentralized light greywater treatment using aerobic digestion and hydrogen peroxide disinfection for non-potable reuse. *Journal of Cleaner Production*, *99*, 305–311.

Teixeira, C. M. L. L., Kirsten, F. V., & Teixeira, P. C. N. (2012). Evaluation of Moringa oleifera seed flour as a flocculating agent for potential biodiesel producer microalgae. *Journal of Applied Phycology*, *24*(3), 557–563.

Valderrama, L. T., Del Campo, C. M., Rodriguez, C. M., De- Bashan, L. E., & Bashan, Y. (2002). Treatment of recalcitrant wastewater from ethanol and citric acid production using the microalga Chlorella vulgaris and the macrophyte Lemna minuscula. *Water Research*, *36*(17), 4185–4192.

Vargas, G., Donoso-Bravo, A., Vergara, C., & Ruiz-Filippi, G. (2016). Assessment of microalgae and nitrifiers activity in a consortium in a continuous operation and the effect of oxygen depletion. *Electronic Journal of Biotechnology*, *23*, 63–68.

Wahidin, S., Idris, A., & Shaleh, S. R. M. (2013). The influence of light intensity and photoperiod on the growth and lipid content of microalgae Nannochloropsis sp. *Bioresource Technology*, *129*, 7–11.

Wang, J.-P., Chen, Y.-Z., Ge, X.-W., & Yu, H.-Q. (2007). Optimization of coagulation–flocculation process for a paper-recycling wastewater treatment using response surface methodology. *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, *302*(1–3), 204–210.

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

Wong, Y.-S., & Tam, N. F. Y. (1998). *Wastewater treatment with algae* (1st editi). New York: Springer· Verlag Berlin Heidelberg.

Wood, A., Uchronska, W., & Valashiya, G. (2001). *Greywater management in dense, informal settlements in South Africa*. South Africa.

Xin, L., Hong-Ying, H., Jia, Y., & Yin-Hu, W. (2010b). Enhancement effect of ethyl-2-methyl acetoacetate on triacylglycerols production by a freshwater microalga, Scenedesmus sp. LX1. *Bioresource Technology*, *101*(24), 9819–9821.

Xin, L., Hong-ying, H., Ke, G., & Ying-xue, S. (2010a). Bioresource Technology Effects of different nitrogen and phosphorus concentrations on the growth , nutrient uptake , and lipid accumulation of a freshwater microalga Scenedesmus sp . *Bioresource Technology*, *101*(14), 5494–5500.

Xu, Y., Purton, S., & Baganz, F. (2013). Chitosan flocculation to aid the harvesting of the microalga Chlorella sorokiniana. *Bioresource Technology*, *129*, 296–301.

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

Zhang, C., Tan, S., Li, J., & Peng, C. (2015). Polishing of Secondary Effluent by a Two-Stage Vertical-Flow Constructed Wetland. *Polish Journal of Environmental Studies*, *24*(2), 923–928.

Zhu, L., Wang, Z., Shu, Q., Takala, J., Hiltunen, E., Feng, P., & Yuan, Z. (2013). Nutrient removal and biodiesel production by integration of freshwater algae cultivation with piggery wastewater treatment. *Water Research*, *47*(13), 4294–4302.