



Faculty of Engineering

**THE EFFECTIVENESS OF A FABRICATED BIO-FILTRATION
SYSTEM IN TREATING THE DOMESTIC GREYWATER**

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Bachelor of Engineering with Honours

(Chemical Engineering)

2017

UNIVERSITI MALAYSIA SARAWAK

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THE EFFECTIVENESS OF A FABRICATED BIO-FILTRATION
SYSTEM IN TREATING THE DOMESTIC GREYWATER

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A dissertation submitted in partial fulfilment
of the requirement for the degree of
Bachelor of Engineering with Honours
(Chemical Engineering)

Faculty of Engineering
Universiti Malaysia Sarawak

2017

Dedicated to my beloved parents and siblings who always bestow us unconditional love, motivations and encouragements. All glory to God in the highest!

ACKNOWLEDGEMENTS

I would like to gratefully acknowledge various people who have been journeyed with me as I have worked on this research. First and foremost, I would like to express my deepest appreciation to my supervisor, Miss Nur Amalina Abdul Samat for her endless guidance and support throughout completing the research. My sincere thanks are also expressed to the technicians and staffs of Chemical Engineering and Energy Sustainability Department for assisting me especially during the fabrication of the system. Besides, I would to thank my parents and family members for helping me survive all the stress from this year and not letting me give up in completing this research. I am highly indebted to Ummie Zulaikha, Belynda Paul, Elizebeth Mayang, Nancy Kalang and Phillip Mapang for their constant assistance and support in completing this research. Last but not least, special thanks are also dedicated to parties who are not mentioned for their willingness to help me directly or indirectly to completion of this project.

ABSTRACT

In many developing countries, domestic wastewater are often discharged without treatment and amongst the various causes of water pollution, the domestic greywater remains as the large contributor of organic pollution in the river. Considering the significant role of river as the main source of freshwater, the level of river pollution needs to be minimized by treating the domestic wastewater, specifically the greywater from the residential areas prior to its release into the drains and rivers. The high cost of installation of many available treatment techniques to control the environment pollution can burden the society especially those from low-income families. Considering the need of domestic wastewater pre-treatment and the economic burden to install the current technology, it is hence necessary to develop a more cost effective wastewater treatment system. Utilizing agriculture waste as a bio-filter media for domestic greywater treatment is an important option to reduce the cost of wastewater treatment system and the accumulation of agricultural waste. Hence, this study will focus on the performance of the agricultural waste such as coconut coir and rice husks as low cost packing media and biofilm material carrier for domestic greywater treatment. The performance of coconut coir and rice husks as packing media in terms of their removal efficiency are evaluated based on several parameters such as turbidity, TSS, COD and BOD₅. Based on the results, coconut coir has better performance than rice husks as packing media in treating the domestic greywater. The removal efficiency achieved by coconut coir packing media in terms of turbidity, TSS, COD and BOD₅ removal from wastewater samples was 63.09%, 49.7%, 38.19% and 43.93% respectively, while the removal efficiency achieved by rice husks was 57.79%, 49.06%, 34.85% and 42.42% respectively. The sufficient amount of dissolved oxygen is important to sustain the aerobic biological action in the system. The performance of each aeration system proposed in treating the wastewater is analysed. The removal efficiency of turbidity, TSS, COD and BOD₅ achieved by coconut coir with the small opening at the inlet pipe as the source of oxygen was 36.65%, 23.08%, 12.36% and 23.29% respectively.

Keyword: domestic greywater, coconut coir, rice husks, packing media

ABSTRAK

Air kumbahan dari domestik merupakan penyumbang terbesar pencemaran organik di sungai-sungai. Air kumbahan domestik mengandungi bahan kimia yang berpunca dari bahan serbuk pencuci, bahan organik dari sinki dan microorganisma pencemar yang boleh mendatangkan kemudaratan kepada hidupan akuatik, menjejaskan kualiti air dan menyebabkan penyakit berjangkit yang memudaratkan boleh kesihatan. Menyedari akan betapa pentingnya sungai sebagai sumber air bersih, maka pencemaran sungai haruslah ditangani dengan merawat air kumbahan domestik terlebih dahulu sebelum dilepaskan ke sungai-sungai. Walaubagaimanapun, kos untuk pemasangan teknik rawatan air kumbahan domestik menjadi satu beban untuk masyarakat terutamanya golongan yang berpendapatan rendah. Hal ini demikian disebabkan system pemasangan rawatan kumbahan air yang memerlukan kos yang tinggi terutamanya kos dari segi peralatan dan bahan kimia yang digunakan. Penggunaan sisa buangan pertanian sebagai media penapis merupakan pilihan yang penting untuk mengurangkan kos sistem rawatan air. Oleh itu, kajian ini menfokuskan pada prestasi sisa buangan pertanian seperti sabut kelapa dan hampas padi sebagai media penapis yang ber bajet rendah untuk rawatan air kumbahan domestik. Prestasi konkrit kelapa dan sekam padi sebagai media pembungkus dari segi kecekapan penyingkiran beberapa parameter seperti kekeruhan, TSS, COD dan BOD5 dinilai. Sabut kelapa mempunyai prestasi lebih baik daripada sekam padi sebagai pembungkus media dalam merawat air kumbahan dalam negeri. Kecekapan penyingkiran kekeruhan, TSS, COD dan BOD5 dari sampel air buangan yang dicapai oleh media pembungkusan sabut kelapa adalah 63.09%, 49.7%, 38.19% dan 43.93%, manakala kecekapan penyingkiran yang dicapai oleh sekam padi ialah 57.79%, 49.06%, 34.85 % Dan 42.42% masing-masing. Jumlah oksigen terlarut yang mencukupi adalah penting untuk mengekalkan tindakan biologi aerobik dalam sistem. Prestasi setiap sistem pengudaraan yang dicadangkan dalam merawat air sisa dianalisis. Kecekapan penyingkiran kekeruhan, TSS, COD dan BOD5 dicapai oleh coir kelapa dengan pembukaan kecil di paip masuk sebagai sumber oksigen masing-masing adalah 36.65%, 23.08%, 12.36% dan 23.29%.

Kata kunci: air kumbahan domestik, sabut kelapa, hampas padi, media penapis

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LIST OF ABBREVIATIONS

BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
DLVO	Derjaguin-Landau-Verwey-Overbeek
FAO	Food and Agriculture Organization of the United Nations
HLR	Hydraulic Loading Rate
HRT	Hydraulic Retention Time
SLR	Surface Loading Rate
SVOC	Semi-volatile organic compound
TSS	Total Suspended Solids
WHO	World Health Organization

NOMENCLATURE

°C	Degree Celsius
M	metre
L/min	Litre per min
mg/L	Milligram per litre
Min	minutes
S	seconds
m ³	cubic metre
m ²	metre square

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Water is one of the fundamental elements in life as it serves essential biological functions and contributes to the development of socio-economic and healthy ecosystems. According to Tang and Ngu (2011), there are over 2.6 billion people experiencing various water crises such as water scarcity and water quality degradation as estimated by the World Health Organization (WHO) and the United Nations Children's Fund (UNICEF). Rapid growth of both population and industrialization have contributed to large amount of wastewater which results in the depletion and pollution of water resources. This statement is supported by Al-Mughalles (2012) which stated that Yemen faces a huge depletion of freshwater and the three main causes of this include the shortages of rainfall, rapid growth of population and the use of groundwater for domestic, industrial and irrigation purposes. Both water scarcity and water pollution have also become a major issue in India as more than 70% of fresh water bodies in India are polluted (Garkal, Mapara, & Prabhune, 2015).

Based on the statistics given by the Department of Statistics Malaysia (2016), the human population in Malaysia rose for about 2.67% from 23.27 million in 2000 to 28.4 million in 2010 and it is estimated that the total population will be further increased to 31.7 million in 2016. This growth in population contributes to the increase in water demand across the country. In Malaysia, about 97% of freshwater source are from river while the remaining are from sub-ground aquifers (Chan, Kamis, & Mohamed, 2014). As reported by the Department of Environment Malaysia in 2012, 278 out of 472 rivers which account for 59% were found to be clean, 161 rivers which accounts for 34% were slightly polluted and 34 rivers which accounts for 7% were polluted (Huang, Ang, Lee, & Lee, 2015). River pollution in Malaysia has become a

major concern due to the discharged of untreated wastewater into the municipal drains and water bodies.

The sources of water pollution can be categorised into two namely, point sources and non-point sources. Domestic wastewater and wastewater from industrial plants are the examples of water pollution point sources. In many developing countries, domestic wastewater often discharged without treatment and amongst the various causes of water pollution, the domestic wastewater remains as the largest contributor of organic pollutant in the river (Radin, Chan, Ghani, & Mat Yasin, 2013). Domestic wastewater contain chemicals which comes from detergents and washing powders, organic materials from kitchen and microbial pollutants which affect the aquatic life, degrade the quality of water and result in infectious diseases and adverse effects to human health.

Kuching, which is the capital city of Sarawak, also experiences rapid growth of population from 496,000 in 2001 to 681,901 in 2010, as reported by Department of Statistics Malaysia (2010). Sarawak River tributaries, situated in the capital city of Sarawak significantly polluted because the domestic wastewater specifically greywater discharged directly into Sarawak River without any treatment (Umami, Selaman, & Said, 2010). Sarawak River was classified as the Class III River which is not suitable for drinking or any recreational activities purposes, requires extensive treatment and has the lowest Dissolved Oxygen measured at only 0.5 mg/L (Kuok, Chiu, & Mah, 2015). As river pollution has becoming the increasingly worrying environmental problem across the country, it implies that serious attention and commitment to treat the domestic wastewater prior to its discharge are vital.

1.2 Problem Statement

Sarawak River tributaries, situated in capital city of Sarawak was significantly polluted and this mainly due to the discharge of the untreated wastewater from the households into the open drains throughout the city (Umami, Selaman, & Said, 2010). For instance, as reported by Ling et.al (2012), the water quality in the Semariang Batu River deteriorates due to the discharge of the domestic wastewater from the household septic tanks as well as kitchens and bathrooms. About 97% of water supply in Malaysia comes from rivers while the remaining are from sub-ground aquifers (Chan, Kamis, &

Mohamed, 2014). Considering the significant role of river as the main source of freshwater, the river pollution needs to be minimized by treating the domestic wastewater, specifically the greywater from the residential areas prior to its release into the drains and rivers.

The high cost of installation of many available treatment techniques to control the environment pollution can burden the society especially those from low-income families. Dubey and Sahu (2014) reported that the wastewater treatment is a major issue nowadays because treating the wastewater requires big cost in terms of equipment and chemicals used. For instance, fixed bed reactor is one of the best methods that is widely applied to treat the domestic greywater. However, the filters installed in the fixed bed reactor are polymer-fiber based filters which are relatively expensive.

Considering the need of domestic wastewater pre-treatment and the economic burden to install the current technology, it is hence necessary to develop a more cost effective wastewater treatment system. According to El Nadi et.al (2014), one of the ways to mitigate environment pollution is by using agricultural waste as a bio-packing media to treat the domestic wastewater before it is discharged to any water bodies. Agricultural waste is often considered to have no economic value and the accumulated amount of these waste may cause further environmental pollution. Utilizing agriculture waste as a bio-packing media for domestic greywater treatment is feasible as it can not only reduce the cost of wastewater treatment system but it can also avoid massive accumulation of agricultural waste. Hence, this research will focus on the study of the performance of the agricultural waste such as coconut coir and rice husks as a low cost packing media and biofilm material carrier for domestic greywater treatment.

1.3 Aim of Research

The aim of this research is to investigate the effectiveness of a fabricated bio-filtration system in treating the domestic greywater as one of the alternatives of cost effective wastewater treatment methods.

1.4 Scope of Research

This research focuses on the treatment of domestic greywater using a designed bio-reactor system with two selected packing media such as coconut coir and rice husks to remove biodegradable organic pollutants. The samples of domestic greywater effluent were collected from Desa Ilmu, Kota Samarahan. All experiments on the fabricated pilot scale system were conducted at Wastewater Engineering Laboratory, Department of Chemical Engineering in the Faculty of Engineering, Universiti Malaysia Sarawak (UNIMAS). The effectiveness of the system were tested based on several water quality parameters namely, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS) and turbidity level. The results were analysed and compared with Standard A and Standard B of Environmental Quality Act (1974). The Gantt chart for this research was attached at **Appendix B: Gantt Chart**.

1.5 Objectives of Research

The objectives of this study are as fourfold below:

I. To compare the performance of coconut coir and rice husks as filter media installed in the bio-reactor in treating the domestic greywater

In this research, natural media such as coconut coir and rice husks are identified as the potential packing media of the bio-reactor to treat domestic greywater. The performance of these natural media are evaluated based on their effectiveness to reduce the values of BOD, COD, TSS and turbidity from the raw domestic greywater.

II. To prove the capability of the agricultural waste packing media as the support for biofilm attachment

The experiment is carried out to observe the growth of microorganisms as biofilm on the surface of coconut coir and rice husks as packing media.

III. To analyse the effects of aeration system on the performance of the bio-reactor and the quality of the treated wastewater

The influence of aeration system on the microbes' growth and activity on the filter media as well as performance of the bioreactor in treating the wastewater is investigated by either providing a small opening at the inlet water pipe or bubbling the air directly into the collected domestic greywater in the bioreactor using air diffuser.

1.6 Research Gap

The performance of coconut coir and rice husks as packing media has never been compared before in any of literatures. In addition, little information is available on the behaviour of organic pollutant removal from wastewater by the use of natural rice husks as packing media currently. The most common application of rice husks in wastewater treatment is as an adsorbent to remove heavy metal such as lead, cadmium, selenium, copper, zinc and mercury from wastewater has attracted considerable attention in recent years (Syuhadah & Rohasliney, 2012). Thus, this research had utilizes the rice husks as packing media to reduce several parameters such as turbidity, TSS, COD and BOD from domestic greywater. Normally, rice husks is used in ash powder form in wastewater treatment, however in this research the rice husks were used without any chemical treatment. The effects of aeration system on the performance of the bioreactor were analysed by substituting the aeration system of direct bubbling by using air diffuser to new method of aeration, by providing small opening at inlet pipe.

1.7 Summary

In summary, using agriculture waste as bio-packing media for domestic greywater treatment is an importance option to reduce the cost of wastewater treatment system. Coconut coir and rice husks had been selected as the agriculture waste to treat domestic greywater. Three objectives were outlined as to compare the performance of coconut coir and rice husks as filter media installed in the bio-reactor in treating the domestic greywater, to prove the capability of the agricultural waste packing media as the support for biofilm attachment and to analyse the effects of aeration system on the performance of the bio-reactor and the quality of the treated wastewater.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter reviews the sources and characteristics of domestic greywater, important treatment of domestic greywater, and the theoretical information of bio-filtration treatment system for treating domestic greywater. This section also discusses the review on the potential use of coconut coir and rice husks as filter media in bio-filtration treatment system.

2.2 Domestic Greywater

Domestic wastewater is the wastewater generated by the society during their daily activities and it can be categorized as blackwater or greywater. Ghunmi et.al (2011) reported that greywater contributes up to the 65 to 75% of the total domestic wastewater.

2.2.1 Sources of Domestic Greywater

There are large amount of domestic greywater being produced daily and its quantity depends on the total water consumption. About 50% to 80% of domestic greywater is generated from the total residential freshwater (Radin, Wurochekke, Hadri, & Kassim, 2015). Jamrah et.al (2011) had stated that the greywater produced is about 69% of total water consumption and Albalawneh and Chang (2015) stated that the amount of greywater range from 50% to 80% of the total wastewater produced by households. Other authors such as Hernandez et.al (2011) and Ghaitidak and Yadav (2013) reported that it accounts for 75% and 65% of the total wastewater volume respectively.