MODULAR INDEPENDENT SEWERAGE TREATMENT SYSTEM DESIGN FOR DOMESTIC RESIDENCE AT WATER VILLAGERS IN SABAH, MALAYSIA

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By

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Chairman : Prof. Hajah Rahinah Ibrahim. PhD
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There is a need to maintain water quality by improving the quality of domestic sewage discharge for reducing coastal contamination at remote water village settlements. The purpose of this study is to develop smallest modular design for an independent sewerage treatment plant (iSTP) system for reducing water contamination at timber water villages. This study focused on conducting quality discharge tests on sewage inflows covering BOD_5, COD, TSS, pH and AN. In addition, it is hypothesized that by controlling 5 person sewage inflows for a timber house, the size of the STP could be reduced by adding oxygen transfer efficiency (OTE) technology with controlled aeration time to maintain quality discharge compatible with Malaysian water standards. This study started with test results of an iSTP 600 L system design and its overall Standard A average according to SPAN (2009). The results help determined the specifications for designing one iSTP 350 L system. The next step was conducting the design calculation for structural loading to timber structures for supporting the iSTP 350 L system design. The results of the study include the development of a proof-of-concept prototype for determining and recommending the design specifications of the smallest iSTP system for timber structures. In essence, the study proposed a 350 L iSTP system prototype which is capable of discharging good water quality. The quality of the new iSTP system prototype was checked against 5 environmental tests (i.e., BOD_5, COD, TSS, AN, pH) and meets the Standard A requirements according to SPAN (2009) with 6 hours aeration time. The 350 L iSTP system is a modular system that enables suspended installation under the structural framing system of a raised floor which allows easy transportation, installation and maintenance in environmentally sensitive locations. The iSTP 350 L system design is unique due to its modular and detachable components with possibilities to be installed on columns and beams. Future studies are recommended to add oil and grease test, use of advanced media and improve the horizontal attachment system of the chambers.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Flasafah

REKA BENTUK SISTEM RAWATAN KUMBAHAN MODULAR TERASING UNTUK PENDUDUK DOMESTIK DI PERKAMPUNGAN AIR DI SABAH, MALAYSIA

Oleh

NAVID NASROLAH MAZANDARANI

Jun 2016

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Terdapat keperluan untuk mengekalkan kualiti air melalui peningkatan kualiti sisa kumbahan domestik terbuang demi mengurangkan pencemaran perairan di penempatan perkampungan air di pendalaman. Kajian ini bertujuan untuk mereka bentuk sebuah sistem loji rawatan kumbahan terasing (iSTP) bagi mengurangkan pencemaran air di penempatan air yang diperbuat dari kayu. Kajian memfokuskan kepada menjalan ujian-ujian ke atas kualiti aliran masuk sisa terbuang yang merangkumi BOD_5, COD, TSS, pH dan AN. Tambahan, kajian menetapkan hipotesis di mana "Dengan mengawal aliran masuk sisa kumbahan terbuang 5 orang yang tinggal di sebuah rumah kayu, saiz STP dapat dikecilkan dengan menambahkan teknologi oxygen transfer efficiency (OTE) yang mengawal waktu pengudaraan yang terkawal untuk mengekalkan kualiti sisa terbuang yang memenuhi standard air Malaysia. Kajian ini dimulakan dengan mengkaji hasil dapatan rekabentuk sistem sebuah iSTP 600 L yang mencapai Standard A secara purata mengikut SPAN (2009) bagi membantu menetapkan spesifikasi mereka bentuk sebuah sistem iSTP 350 L. Langkah berikutnya adalah menjalankan pergiraan reka bentuk struktur bebanan yang mampu menyokong reka bentuk sistem iSTP 350 L. Hasil dapatan kajian merangkumi pembangunan prototaip proof-of-concept bagi menetapkan dan mencadangkan spesifikasi reka bentuk sistem iSTP terkecil untuk struktur kayu. Kesimpulan dari kajian ini telah mencadangkan sebuah prototaip iSTP 350 L yang mampu mengeluarkan sisa kumbahan yang baik kualiti airnya. Kualiti prototaip sistem iSTP baharu disemak dengan 5 ujian alam persekitaran (iaitu BOD_5, COD, TSS, AN dan pH) dan ianya memenuhi keperluan Standard A mengikut SPAN (2009) dengan tempoh pengudaraan selama 6 jam. Kelebihan sistem 350 L iSTP ini adalah, ianya sebuah sistem yang modular yang boleh digantung di bawah sistem kerangka struktur bangunan yang berpanggung. Reka bentuk modular turut memudahkan transportasi, pemasangan dan penyelenggaraan dalam lokasi persekitaran yang sensitif. Reka bentuk sistem iSTP 350 L adalah unik kerana ianya modular dan komponen-komponennya boleh diasingkan bagi membolehkannya mudah dipasang di atas tiang dan rasuk rumah-rumah kayu. Cadangan kajian pada masa hadapan termasuklah pengujian minyak dan gris, penggunaan media termaju dan menambahbaik pemasangan mendatar pada komponen-komponen tersebut.

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I certify that a Thesis Examination Committee has met on 29 JUNE 2016 to conduct the final examination of Navid Nasrolah Mazandarani on his thesis entitled "MODULAR INDEPENDENT SEWERAGE TREATMENT SYSTEM DESIGN FOR DOMESTIC RESIDENCE AT WATER VILLAGERS IN SABAH" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy. Members of the Thesis Examination Committee were as follows:

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LIST OF ABBREVIATIONS

IHR	International Human Regulation
iSTP	Independent Sewerage Treatment Plant
BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
TSS	Total Suspended Solids
AN	Ammonia & Nitrogen
pH	Hiring Potential
O & G	Oil and Grease
HRT	Hydraulic Retention Time
OTE	Oxygen Transfer Efficiency
DO	Demand Oxygen
PE	Population Equivaleut

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter describes the overview of this research. It introduces the indigenous timber houses and the industrialized timber houses. This chapter also covers the background of this study, problem statement, research design framework, scope of the study, definitions of key terms, and outline of the study.

1.2 Indigenous Timber Houses

Indigenous timber houses are made of wood and foliage and have a simple structure. These houses can be built everywhere in Malaysia. Some of them are built on the water at the beach and some of them on the ground. Due to the need of indigenous people to live along the water, these homes can be found in the surrounding waters (Fien et al., 2008). It is estimated that the population of world's indigenous people is about 370 million from 70 countries (America et al., 2012). They are different in retaining social, cultural, economic and political characteristics that are distinct from those of the dominant society in which they live (Harry & Shelton, 2000). In Malaysia, most of these houses are available in Sabah, the second largest state. This state is on the third largest island in the world (Combrink et al., 2008). Sabah is surrounded by South China Sea in the west, the Sulu Sea in the northeast and the Celebes Sea in the east (Azizi, 2014). The population of Sabah is about 2 million and is divided into three main indigenous groups. The first one is Kadazan-Dusun, the largest number of people who are living in Sabah (Combrink et al., 2008). They live in the interior plains. The second group in Sabah is the *Muruts*. They live in the interior region close to the borders of Sarawak and Kalimantan. The third group is the Bajaus. Bajaus live in the eastern and western coasts of Sabah (Shaari & Law, 2014). The main skills of these indigenous people are fishing and rice farming. Due to this, they need to live near the water and which led many to call them water people of Sabah. Bajaus started to live in Sabah about 200 years ago. They are living between a nomadic and sedentary life. Their houses are on the water but not far from the land (Combrink et al., 2008). Most young Bajaus swim around their houses and catch fish, octopus and lobsters. They live with their family in timber houses along coastal areas. Bajau people prefer traditional living at oceans (Rahinah Ibrahim, 2015). However, they come to the land to trade fish for rice. The Bajau children catch fish and octopus early in their life (Belud & Sama, 2008). Every day, Bajau children try to learn to catch fish and they lack opportunity to go to school. They cannot live on land and they prefer to live on sea or oceans and build wooden huts out on the water (Komunikasi, 2010). This situation can create problems for the Bajau people and they do not have any information about the environment and hygiene and they can cause problem to the environment (Combrink et al., 2008).

1.3 Industrializing Houses in Timber

Nowadays, industrialized houses are found in all parts of the world and many indigenous people are living in these houses. Malaysia is one of the countries that have the most number of Industrialized houses (Jabar, 2014). The variety of geographic location and climates in different countries define the structures of these houses which are consistent with the surrounding area and climate. The houses are different in shapes and materials in different parts of the world (Pacific, Islanders, & New Zealand, 2002). Industrialized houses were started in the 1960's (Balasbaneh, Kadir, & Marsono, 2013). Malaysia followed the European countries and tried to develop industrialized house projects. Industrialized houses are a construction system industry that entails special manufacturing and assembly with minimum labour and site work which is considered an advantage (Nor et al., 2012). Another important advantage of industrialized houses is the integrated manufacturing and construction process (Balasbaneh et al., 2013). Ordinary people are the common dwellers of these types of houses. These houses are also commonly built for tourist attractions at the coasts. According to the national indigenous housing research (2009), industrialized houses are helpful for the health as well. As mentioned earlier, these houses are also used as temporary residences. Industrialized houses are a major homestay with the potential to enhance the health of people who live in the city. Many people may be interested in living in these homes for a short time or even for long-term (Partnership, Housing, & Review, 2013). Same as indigenous houses, the timber architecture has a wood design structure. All components of these houses are made of wooden materials such as the walls, floors, and roofs. Today, most industrialized houses are built with other materials such as mud and brick (Tyagi et al., 2011). The structure of industrialized houses has a simple architecture. Separate parts of the house are manufactured in factories and are assembled on site. Today, Industrialized houses are built in many different countries (Kamar & Hamid, 2011). In Sabah of Malaysia, the construction industry has changed its direction from traditional methods to industrialized house manufacturing and the like. These types of projects have changed into product based and the prefabricated system or architectural system is transferred to manufacturing in some countries including Australia, Hong Kong, Singapore, United Kingdom, and the United States (Nor et al., 2012). The advantages of Industrial Building Systems are implementation of prefabrication in the construction industry which has enhanced productivity and improved its quality (Athukorala, 1996). Other advantages include shortened construction time, lower overall construction cost, improved quality, enhanced durability, better architectural appearance, enhanced occupational health and safety, material conservation, less construction site waste, less environmental emissions, and the reduction of energy and water consumption (Nor et al., 2012). The Malaysian government tries to encourage the construction industry to move toward Industrialized Building Systems which can produce high volumes of industrialized houses with lower expenses for people from different socio-economic background (Thanoon, 2003). The industrialized houses have an integrated manufacturing and construction process with well-planned organization for efficient management (Musa et al., 2014). This style of management helps to prepare and control the resources that are used for activities and results. These types of houses can be supported by the use of highly developed components. Today, climate change and resource scarcity combined with the need of cleaner environments and an ever growing economic scarcity problem threatens our ability to reach this goal (Kamar et al., 2011). Industrialized houses can be an alternative option in maintaining construction sustainability. This opportunity

can control human resources and expenses in scheduling and staffing. In fact, this entails a shortened construction period that increases the quality of work and building (Embong, 2000). In addition, another advantage of industrialized houses is they do not require complicated construction (Hussin et al., 2013). According to the Construction Industry Development Board (CIDB), industrialized houses provide a construction system that is comparable with manufacturing in a controlled environment. This construction can be transported, positioned and assembled at the same time and without extra site woks (Nor et al., 2012).

1.4 Background of the Study

Today, indigenous houses are a major part of some communities' well-being. In the past, the houses belonged to the indigenous people only and no one else used to live in them. Indigenous houses are houses that are very simple in structure and are made of wood. Foliage are also used for building these houses (Richmond & Ross, 2009). In fact, the materials used for this type of houses are very simple including materials used for doors, windows, lavatories, kitchens. When modern sciences and technology are developed and used in the construction of these houses, local people became eager to use them. In fact, these houses with simple structure have basic technology for indigenous people and, nowadays, local people are interested in using this basic technology (Lohmann, 2009). Indigenous houses exist in all parts of the world, but what make these houses different are their simple structure and their usage by ordinary people, and also, they can be spacious and provide physical comfort for people. Most of these houses are built beside water, because indigenous people needed water for washing and drinking, hence, they prefer to build their houses close to the waters. Nowadays, this culture is still alive (Akinnifesi et al., 2008). On the other hand, these houses can negatively affect the environment. As mentioned earlier, these homes have the lowest standards of living and normally lower class of people, such as indigenous people, live in them. Thus, some basic facilities have been provided in these houses which can help to fix some of the issues but there are still some problems (Bromley, 2009). One of the features that can create problem is the toilet. Toilet facilities are one of the issues that the indigenous houses have faced before and after the development. This means that before improving a local home, some features may be added such as toilet, but indigenous people prefer the river side or inside the water rather than going to the bathroom. This is another reason behind indigenous peoples' preference to build their houses near the water. Unfortunately, today's indigenous people continue to wash themselves in the waters surrounding their houses, such as rivers and sea. In fact, this is a major issue that can create problems for the environment and other people. Raw sewage and water contamination which are close to people's living area can transfer disease (Akinnifesi et al., 2008).

Figure 1.1: Timber House in Sabah, (Sources are Ibrahim 2015)

Furthermore, given that the developed indigenous houses have toilets, they still create raw sewerage and water contamination, because the toilet area is inside the houses with no sewerage system to transfer the sewerage and contaminated water to wastewater treatment plant. The important point regarding raw sewerage and water contamination is the treatment plant. In fact, in order to reduce the pollution in the environment and prevent the spread of infection, raw sewerage and polluted water that come from people need to be treated (Struthers & Eschiti, 2005). Today, the indigenous houses that have toilet facilities transfer the waste water and raw sewerages into the rivers and the sea directly. This is the negative effect of these types of houses that existed from the beginning till now (Yuan, 2002)

Figure 1.2: Broken Pipes to Central STP at Water Village, (Sources are Ibrahim 2015)

Transferring raw sewage from the houses is complicated. For example, special types of pipes are needed for transferring the raw sewage and wastewater from the houses to the wastewater treatment plant. Moreover, since indigenous houses are far from the wastewater treatment plant, they need a lot of pipes and special pumps for transferring the raw sewage and wastewater. Therefore, it is not economically efficient (Je et al., 2000). In addition, although these homes are surrounded by waters, maintenance of sewerage systems is difficult and impossible. In fact, some of these houses are built on water, and hence, building a central system for collecting raw sewage is difficult on the water (William, 1997). In some cases, there are proposals to collect sewage from the tank after a few days and the sewage will be drained by truck, but it is difficult a difficult procedure, and in some areas, heavy cars such as trucks cannot pass. If left unresolved, this can lead to outbreak of disease. Overall, the discharge of sewage water is the best and easiest way (Bruce E, 2007).

Figure 1.3: Low Tide Condition, (Sources are Ibrahim 2015)

Studies have shown that flowing water acts as a filtration system and the contamination of water will be reduced while flowing. In fact, when water is flowing in a river, solids are suspend in the water and then the suspended solids will be gradually divided into smaller parts in the water (Quayle et al., 2009). Due to the presence of sand and gravel in the river, suspended solids like to stay with sand and gravel. Therefore, water contamination will be reduced automatically. But these waters have certain standards that introducing excessive suspended solids into it can disturb the natural cycle and endanger organisms in the water (Mucha et al., 2005).Malaysia is one of the countries having a large number of indigenous people and there are plenty of indigenous houses in different parts of Malaysia. So there is no doubt that the country is faced with a large amount of raw sewage in nature (Said, 1996). Today, the Malaysian government has tried to create indigenous houses with basic facilities. Indigenous people are

encouraged to use these interior facilities and they do not use rivers and the sea for washing. However, these efforts have been inconclusive because of two major problems arising. The first problem is that the government is forced to build houses on the water because the indigenous people have the desire to live in these houses, but as noted above, the indigenous houses are far away from wastewater plant and this creates problems for transferring the raw sewage. To this, the government build absorption wells, a traditional wastewater treatment method. In this method, raw sewage enters into wells and sewage water is absorbed, suspended solids that comes from sewage uptake over time is converted to sludge. One of the disadvantages of this method is that the cycle of groundwater will be polluted by absorption of sewage (Yuan, 2002). The second problem lies in the culture of the indigenous people. Although new indigenous houses have some facilities, they prefer to wash themselves in the rivers and the sea. This culture is of instinct that was ingrained from ancient times until today, which is interwoven with them (Godoy et al., 2010).

1.5 Problem Statement

Today, the application of advanced wastewater treatment systems is common and crucial around the world and the emphasis is on the standardization process of wastewater treatment. In some parts of the world, due to the unique geography of that area, wastewater undergoes changes (Whittington et al., 2009). Houses on water are prominent cases of lack of standard in wastewater treatment plant. In this type of houses, because of the high cost and difficulty of installation of wastewater treatment plant, wastewater is directly disposed to water. In fact, domestic wastewater treatment plants require a large area to dispose wastewater from indigenous houses and since such areas are not easy to find, wastewater is directly disposed to water bodies. The presence of raw sewage in the environment is causing some problems. These problems can also be dangerous for humans and environment (Giltner, Habash, & Burrows, 2010). Transmission of dangerous diseases is one of the problems that arise from human raw sewage. Cholera is a disease that is transmitted to humans through raw sewage. Cholera is an infectious disease that is transmitted through contaminated water and food. Cholera bacterium has the ability to move from one place to another and it can have different reactions in different situations (Ghose, 2011). Cholera bacteria are transposable through humidity and environment and it is not restricted to the displacement. In this case, cholera bacteria can move long distances and can be transmitted to humans through food and water. For example, if plants are fed from water that carries cholera bacteria, the plant is a carrier of cholera bacteria and it can be transferred to humans or animals. One of the modes of transmission of cholera bacteria in water is through faeces. Therefore, health and environmental conditions do play an important role in the transmission of the cholera bacteria. In poor countries, the risks of further spreading of the disease are high. Moreover, many of these countries do not have true wastewater treatment plant and raw sewage is transferred to environment directly. In 1994, in a refugee camp in Goma, Democratic Republic of the Congo, a major epidemic took place and 23,800 deaths occurred within one month (Wong, Liu, Liu, Chung, & Shimada, 2002). The cholera epidemic of wastewater was among the first diseases in the list of international human regulation (IHR). According to regulations established by the UN General Assembly, all countries need to control raw sewage and avoid disposing raw sewage into nature without treatment (Goldstein, 2012). Thus, the spread of the disease must be prevented. This imperative is applicable

for indigenous houses or water village houses that transfer raw sewage into water directly (Whittington et al., 2009). Unfortunately, most of these types of homes are in countries that are considered tourist attraction and do not follow the standards set forth in the IHR list. There are several reasons why a house lacks a purification system; one of them could be the cost and the second one is the problem of transferring sewage to the location of treatment plant. The study refers to the transferring part. These are the two main reasons why these homes do not have a sewerage system or treatment plant and cause outbreaks of disease (Goldstein, 2012). The second problem which stems from raw wastewater is uncontrolled growth of aquatic plants. Actually, human faeces have organic matter that contains phosphates and nitrates. These organic materials are considered as fertilizer. When raw sewage enters the water without treatment, phosphates and nitrates in raw sewage are the best food for growing plants in water and cause excessive growth of aquatic plants (Michigan, 2012). Excessive growth of aquatic plants cause problems. This problem can be explained as follows:

i. Uncontrolled growth of plants covers water surface and prevents recreational activities such as swimming, fishing, and boating;
ii. Excessive growth of aquatic plants creates a shelter for small fish which can lead to increase of the fish population.
iii. Excessive aquatic plants can help reduce the amount of oxygen and can cause the death of aquatic plants. Water has standard oxygen and excessive growth of aquatic plants can cause disruption in the balance.

Therefore, the study posits that there is a need to maintain water quality by improving domestic sewerage discharge for reducing contamination in remote water village settlements.

1.6 Research Design Framework

This section explains how the researcher designed the research framework. It highlights the research questions (RQ_s) and research objectives (RO_s) and summarizes the overall outcomes. Details of the research workflow are presented in Chapter 3.

Table 1.1: Eagle research design framework (adopted from Ibrahim, 2011)

Title: Developing an independent sewerage treatment plant system for reducing water contamination at water villages in Sabah					
Problem Statement: There is a need to improve water quality by improving domestic sewerage discharge for reducing contamination in remote water village settlements.					
Main RQ: What are the main components for developing an independent sewerage treatment plant system (How1, what) for reducing water contamination (how2) at water villages in Sabah (who)?					
RQ Construct	**Description of RQ Construct**	**Description of SUB-RQ**	**Strategy of Inquiry**	**Expected Result**	**knowledge contribution**
WHO	**WATER VILLAGES**	**SUB-RQ 1:** What is the socio-cultural background of indigenous residents in water villages in Sabah? **RO 1:** To understand the socio-cultural background of indigenous residents of water villages in Sabah.	**LR**	**Output 1:** Documentation of socio-cultural background of indigenous residents of water villages in Sabah.	**Knowledge 1:** Understanding the socio-cultural background of indigenous residents of water villages in Sabah
WHAT	**INDEPENDENT SEWERAGE TREATMENT PLANT SYSTEM**	**SUB-RQ 2:** What are the appropriate independent STP systems and environmental standards for developing an efficient new system design for water villages in Sabah? **RO 2:** To Identify and recommend the appropriate independent STP system and environmental standard for developing an efficient new system design for water villages in Sabah.	**LR**	**Output 2:** 2.1. Documentation of current STP standards for design. 2.2.Documentation of regulatory standards for Malaysian wastewater 2.3. Identification of main components of STP system 2.4. Recommendation for specification design of modular of independent STP.	**Knowledge 2:** Recommendation for design specification of modular of independent STP for water villages in Sabah.

HOW_2	**REDUCE WATER CONTAMINATION**	**SUB-RQ 4:** How could an efficient independent STP system be designed for reducing water contamination at water villages in Sabah? **RO 4:** To determine the most efficient independent STP system be designed for reducing water contamination at water villages in Sabah.	**Experiment**	**Output 4:** 4.1. Recommendation regarding number of chambers, and optimized operating volume for each chamber. 4.2. Recommendation for operational limitations of proposes independent STP. 4.3. design specification proposal for independent STP system	**Knowledge 4:** Design specification recommendation for independent STP system for water village in Sabah.
HOW_1	**DEVELOP INDEPENDENT STP SYSTEM**	**SUB-RQ 3:** How could someone easily install an independent STP under timber framing structure at water villages in Sabah? **RO 3:** To recommend the best method to easily install an independent iSTP under timber framing structure at water villages in Sabah	**LR**	**Output 3:** 3.1. Timber framing load design calculation 3.2. Recommended Modular design of independent STP. 3.3. Independent STP Prototype for timber framing installation.	**Knowledge 3:** 3.1. Structural loading design recommendation for timber frame. 3.2. Independent STP prototype for timber frame installation. 3.3. Guideline for installing modular independent STP for timber frame.

1.6.1 Research Questions

The following research paradigm is based within the design development discipline.

Main Research Questions

What are the main components for developing an independent sewerage treatment plant system for reducing water contamination at water villages in Sabah?

Sub- Research Questions

- What is the socio-cultural background of indigenous residents of water villages in Sabah?
- What are the appropriate independent STP system and environmental standard for developing an efficient new system design for water villages in Sabah?
- How could an efficient independent STP system be designed for reducing water contamination at water villages in Sabah?
  How could someone easily install an independent STP under timber framing structure at water villages in Sabah?

1.6.2 Research Objectives

The objectives of this study are:

- To understand the socio-cultural background of indigenous residents of water villages in Sabah.
- To Identify and recommend the appropriate independent STP system and environmental standard for developing an efficient new system design for water villages in Sabah within a design development paradigm.
- To determine the most efficient independent STP system designed for reducing water contamination at water villages in Sabah.
- To recommend the best method to easily install an independent STP under timber framing structure at water villages in Sabah**.**

1.6.3 Summary of Research Design

This research is an experimental research method that has four main phases. The first phase concerns the socio-cultural background of indigenous residents of water villages in Sabah. The second phase is about water contamination. The researcher tried to understand water quality and 5 major environmental tests are used for checking the quality of sewage. The third phase is about designing an independent sewerage treatment plant system. The final phase is about developing an iSTP system to recommend as the best method to easily install an independent iSTP under timber framing.

1.7 Scope of Study

This study covers a small treatment system design for industrialized timber houses with simple structure similar to a septic tank that treats small package of raw sewage that comes out form sewerage pipe. In fact, this research tries to solve the problems that these types of buildings have created. This study focuses on different parts of sewerage system and treatment plant to find out the best way for solving the problem.

1.8 Definitions of Key Terms

Indigenous Houses

Indigenous houses are houses that indigenous people build and are made of wood and foliage. These houses have very simple structures without any basic facilities.

Water Contamination

Contaminated water is in the natural waters that are not potable and recyclable. Today, there are different types of polluted waters which are contaminated by someone or something.

Cholera

Cholera is a bacterial infection. It is caused by drinking water contaminated with vibrio cholera bacteria, or by eating food that has been in contact with contaminated water.

Sewerage

It is a system or treatment process used for wastewater and sewage

Sewage

It is human urine and faeces.

Independent Sewerage Treatment Plant

Wastewater treatment system is a system that treats the wastewater. This plant can be very large such as for a factory or small such as a septic tank for a bungalow house.

1.9 Outline of the Thesis

This thesis is divided into six chapters as follows:

Chapter One presents the overall introduction of the research. It examines the background of the research problems as well as the aims and objectives of the research that are formulated based on the area of study. The theoretical framework and the formation of research questions are illustrated and discussed in this chapter.

Chapter Two discusses the literature review of water contamination and independent sewerage treatment plant system and modular integration.

Chapter Three presents the experimental research methodology. The experimental method evaluated two prototype of iSTP design system (600 L & 350 L). Data collection and data analysis are also discussed in this chapter.

Chapter Four presents the results gathered from all of the analysis tests (BOD5, COD, TSS, AN, and PH). In addition, the experimental method which includes the laboratory test and analysis of the test will also be presented. It also presents the average results of outlet discharge in iSTP 600 L system design and iSTP 350 L system design and how the researcher specified a smaller iSTP.

Chapter Five concentrates on the average results of iSTP 350 L system design and the use of prototype dimension form new modular ISTP 350 L system design. The researcher also presents the assembly part in this chapter.

Chapter Six covers the answers to research questions, knowledge claims, limitation of study, impacts of study and recommendations for future studies.

REFERENCES

Adhvaryu, A., Sung, C., & Erhan, S. Z. (2005). Fatty Acids and Antioxidant Effects on Grease Microstructures . Industrial Crops And Products, 21(2), 285–291.

Aghata. (2005). Kg (Pvc) Pipes & Fittings. Washington: Wastewater Piping and Working with Water Corporation

Aguirre, L. A., Rodrigues, D. D., Lima, S. T., & Martinez, C. B. (2008). Dynamical Prediction And Pattern Mapping in Short-Term Load Forecasting. International Journal of Electrical Power & Energy Systems, 30(1), 73–82.

Akinnifesi, F. K., Mhango, J., Sileshi, G., & Chilanga, T. (2008). Early Growth And Survival of Three Miombo Woodland Indigenous Fruit Tree Species Under Fertilizer, Manure and Dry-Season Irrigation In Southern Malawi. Forest Ecology And Management, 255(3-4), 546–557.

Alberta. (2009). Alberta Private Sewage Systems. Fatty Acids and Antioxidant Effects on Grease Microstructures . Industrial Crops And Products, 21(2), 285–291.

Ali, M. T., Mokhtar, M., Chiesa, M., & Armstrong, P. (2011). A Cooling Change-Point Model Of Community-Aggregate Electrical Load. Energy And Buildings, 43(1), 28–37.

America, L., Assembly, G., Declaration, T., Day, T. I., Peoples, I., United, T., & Declaration, N. (2012). Indigenous Peoples : New Dehli. India and the Rights Of Indigenous Peoples

American, N. (2006). About North American Pipe Plant Locations and Service Areas: California. Modern Sewer Design.

Andro. Pollution Prevention Guidelines (2006): California. Currenta Gmbh & Co. Ohg.

Athukorala, P. (1996). Foreign Investment and Industrialization in Malaysia : Exports , Employment and Spillovers Premachandra Athukorala Jayant Menon. Asian Economic, 10(I), 1–16.

Avenue, O. T., & B-, S. (2005). Oregon Department of Environmental Quality: California. Currenta Gmbh & Co. Ohg.

Azizi, B. (2014). The Architectural and Cultural Heritage of Sabah - The Rungus Longhouse. EDP Sciences, 12(3), 1–12.

Azzurro, E., Matiddi, M., Fanelli, E., Guidetti, P., La Mesa, G., Scarpato, A., & Axiak, V. (2010). Sewage Pollution Impact on Mediterranean Rocky-Reef Fish Assemblages. Marine Environmental Research, 69(5), 390–7.

Balasbaneh, A. T., Kadir, A., & Marsono, B. (2013). Life Cycle Assessment of IBS in Malaysia and Comparing Human Health on Timber And Concrete Pre-Cast. Journal of Applied Scientific, Engineering and Technology, 6(24), 4697–4702.

Ball, L. (2009). Cholera and the Pump on Broad Street, Journal of Environmental Management, 86(1), 63–79.

Balmoral, H. O. & F. (2010). Balmor Al Tanks. Journal of Environmental Management, 86(1), 90-100.

Baquerizo, G., Maestre, J. P., Machado, V. C., Gamisans, X., & Gabriel, D. (2009). Long-Term Ammonia Removal in a Coconut Fiber-Packed Biofilter: Analysis of Fractionation and Reactor Performance Under Steady-State and Transient Conditions. Water Research, 43(8), 2293–301.

Barkovskii, A. L., Green, C., & Hurley, D. (2010). The Occurrence, Spatial and Temporal Distribution, and Environmental Routes of Tetracycline Resistance and Integrase Genes in Crassostrea Virginica Beds. Marine Pollution Bulletin, 60(12), 2215–24.

Barrena, R., D'imporzano, G., Pons, S., Gea, T., Artola, A., Zquez, F., Adani, F. (2009). in Search of a Reliable Technique for the Determination of the Biological Stability of The Organic Matterin the Mechanical-Biological Treated Waste. Journal of Hazardous Materials, 162(2-3), 1065–1072.

Bayer, A. (2010). Wastewater Treatment Plants. Leverkusen: Currenta Gmbh & Co. Ohg.

Belud, K., & Sama, B. (2008). Duang : The Semiotic Interpretation and Perception of the Bajau-Sama Community In Sabah. Sari 26, 26(3), 71–78.

Bezdek, R. H., Wendling, R. M., & Diperna, P. (2008). Environmental Protection, The Economy, and Jobs: National and Regional Analyses. Journal of Environmental Management, 86(1), 63–79.

British Columbia. (2005). How To Find A Septic Tank. Manchester. Environmental Protection, The Economy, and Jobs: National and Regional Analyses. Journal of Environmental Management, 86(1), 63–79.

Bromley, D. W. (2009). Formalising Property Relations in the Developing World: the Wrong Prescription For The Wrong Malady. Land Use Policy, 26(1), 20–27.

Brostow, W., Lobland, Pal, S., & Singh, R. P. (2009). Polymeric Flocculants for Wastewater And. Materials Education, 31(3), 157–166.

Bruce E. Macdonald, Jagc, U. (2007). Published from Appropriated Funds by Authority of the Judge Advocate General in Accordance With Navy Publications and Printing Regulations P-35. International Criminal Court Complementarity, 2(36), 100–150.

Chan, Y. J., Chong, M. F., Law, C. L., & Hassell, D. G. (2009). A Review on Anaerobic–Aerobic Treatment of Industrial and Municipal Wastewater. Chemical Engineering Journal, 155(1-2), 1–18.

Chaurette, J. (2005). Tutorial. Montrea. Chemical Engineering Journal, 155(1-2), 1–18.

Chen, H., Ye, T., Qiu, B., Chen, G., & Chen, X. (2008). A Novel Approach Based on Ferricyanide-Mediator Immobilized in an Ion-Exchangeable Biosensing Film for the Determination Of Biochemical Oxygen Demand. Analytica Chimica Acta, 612(1), 75–82.

Chen, , (2011). Reducing H2s Production by O2 Feedback Control During Large-Scale Sewage Sludge Composting. Waste Management (New York, N.Y.), 31(1), 65–70.

Combrink, H. J. B., Soderberg, C., Boutin, M. E., Boutin, A. Y., Wise, M. R., Zook, M., & Zook, M. (2008). Indigenous Groups of Sabah : An Annotated Bibliography of Linguistic and Anthropological Sources Compiled: Sabah . The Sabah Museum Monograph.

Contreras, E. M., Bertola, N. C., Giannuzzi, L., & Zaritzky, N. E. (2002). A Modified Method To Determine Biomass Concentration as Cod in Pure Cultures and in Activated Sludge Systems. Water Sa, 28(4), 463–467.

David. (2006). Asset Management : A Guide For Water And Wastewater Systems 2006 Edition Prepared By : Environmental Finance Center. Water And Wastewater Industry, 12(4), 1–91.

David. (2012). Polyethylene Pipe And Fittings. (Innovating Water, Ed.). Washington: Promains.

Devan, H. (2012). Water & Wastewater Construction October 2012. (S. Drawings Are Compiled Into The First Edition Of The Manual., Ed.). Texas. Retrieved From Http://Www.Dallascityhall.Com/Dwu/Dwu_Design_Standards.Htm

Deziel, N. (2014). Pharmaceuticals In Wastewater Treatment Plant Effluent Waters. University Of Minnesota, Morris, 1(2), 1–20.

Diya'uddeen, B, Daud, & Abdul Aziz, A. R. (2011). Treatment Technologies for Petroleum Refinery Effluents: A Review. Process Safety and Environmental Protection, 89(2), 95–105.

Dominguez, D., & Gujer, W. (2006). Evolution Of A Wastewater Treatment Plant Challenges Traditional Design Concepts. Water Research, 40(7), 1389–1396.

Dozier, M. C. (2005). What Is Water Pollution Alabama. Journal of Environmental Management, 86(1), 63–79.

Edward, B. (2003). Water For The World. South Africa. Water Sea, 28(4), 463–467.

Eggen, O. (2002). Modular Product Development, 1–12. Treatment Technologies for Petroleum Refinery Effluents: A Review. Process Safety and Environmental Protection, 89(2), 95–105.

Embong, A. R. (2000). Social Transformation , The State And The Middle Classes In Post-Independence Malaysia, 34(3), 524–547.

Emerson Process Management. (2009). Dissolved Oxygen Measurement in Wastewater Treatment. Water and Wastewater Industry, (January), 1–4.

Enderlein, U. S., E. Enderlein, R., & Williams, W. P. (1997). Water Quality Requirements. Water Pollution Control. Torento: Department Water Quality Management Principles.

Environmental Protection Agency, I. (1997). Wastewater Treatment Manuals. Management, 13.

Epa. (2004). Primer For Municipal Wastewater Treatment Systems. Washington: EPA.

Epa. (2005). Managing Your Septic System Septic Tank Pump-Out. Rhode Island. Dissolved Oxygen Measurement in Wastewater Treatment. Water and Wastewater Industry, (January), 1–4.

Fadavi, A., & Chisti, Y. (2005). Gas–Liquid Mass Transfer in a Novel Forced Circulation Loop Reactor. Chemical Engineering Journal, 112(1-3), 73–80.

Farm, O. (1997). Septic Smart New Ideas for Household Septic Systems on Difficult Sites. Canada: Department of Wastewater.

Farrell-Poe, K. Maintaining Your Septic Tank (2010). Rhode Island. Dissolved Oxygen Measurement in Wastewater Treatment. Water and Wastewater Industry, (January), 1–4.

Fdot. (2013). Structures Design Guidelines. Florida: Florida Department of Transportation.

Field Operations Division. (1991). Operation & Maintenance Guide for Imfoff Tank & Oxidation Pond Wastewater Treatment Plants. American Journal of Public Health (New York, N.Y. : 1912).

Field, F. (1997). Wastewater Systems Bureau Of Water Nonpoint Source Section, Canada: Department of Health Minimum Standards for Design and Construction.

Fien, J. (2008). Towards A Design Framework for Remote Indigenous Housing Authored. Australian.: Department of Water Contamination.

Freese, D. L. T. And D. J. N. (2003). Manual For Testing of Water and Wastewater Treatment. Umgeni. Rhode Island. Dissolved Oxygen Measurement in Wastewater Treatment. Water and Wastewater Industry, (January), 1-10.

Frerichs, R. R., Keim, P. S., Barrais, R., & Piarroux, R. (2012). Nepalese Origin of Cholera Epidemic In Haiti. Clinical Microbiology and Infection : The Official Publication of the European Society of Clinical Microbiology and Infectious Diseases, 18(6), E158–63.

Froh, J. J., Yurkewicz, C., & Kashdan, T. B. (2009). Gratitude and Subjective Well-Being in Early Adolescence: Examining Gender Differences. Journal of Adolescence, 32(3), 633–50.

Ghose, A. C. (2011). Lessons from Cholera & Vibrio Cholerae. The Indian Journal of Medical Research, 133(February), 164–70.

Giltner, C. L., Habash, M., & Burrows, L. L. (2010). Pseudomonas Aeruginosa Minor Pilins are Incorporated into Type Iv Pili. Journal of Molecular Biology, 398(3), 444–61.

Gmbh, L. P. (2010). Screw Pumps & Systems (Leistritz). Allendale: Lesistritz. Rhode Island. Dissolved Oxygen Measurement in Wastewater Treatment. Water and Wastewater Industry, (January), 1-30.

Godoy, R., Zeinalova, E., Reyes-Garc á, V., Huanca, T., Kosiewicz, H., Leonard, W. R., & Tanner, S. (2010). Does Civilization Cause Discontentment Among Indigenous Amazonians Test of Empirical Data from the Tsimane' of Bolivia. Journal of Economic Psychology, 31(4), 587–598.

Goel, A. (2012). Recent Trends in Technologies in Sewerage System Ministry of Urban Development. (M. Of U. Development, Ed.). New Delhi: Government of India.

Goldstein, B. D. (2012). John Snow, The Broad Street Pump and the Precautionary Principle. Environmental Development, 1(1), 3–9.

Golfinopoulos, S. K., & Arhonditsis, G. B. (2002). Multiple Regression Models : A Methodology for Evaluating Trihalomethane Concentrations in Drinking Water from Raw Water Characteristics. Chemosphere, 47(3), 1007–1018.

Goli, S., Arokiasamy, P., & Chattopadhayay, A. (2011). Living and Health Conditions of Selected Cities in India: Setting Priorities for the National Urban Health Mission. Cities, 28(5), 461–469.

Gorkin, R., Clime, L., Madou, M., & Kido, H. (2010). Pneumatic Pumping in Centrifugal Microfluidic Platforms. Microfluidics and Nanofluidics, 9(2-3), 541–549.

Goss, M., & Richards, C. (2008). Development of a Risk-Based Index for Source Water Protection Planning, Which Supports the Reduction of Pathogens from Agricultural Activity Entering Water Resources. Journal of Environmental Management, 87(4), 623–32.

Gössling, S., Peeters, P., Hall, C. M., Ceron, J.-P., Dubois, G., Lehmann, L. V., & Scott, D. (2012). Tourism and Water Use: Supply, Demand, and Security. An International Review. Tourism Management, 33(1), 1–15.

Gudeman, L. F., & Peppas, N. A. (1995). Ph-Sensitive Membranes from Poly (Vinyl Alcohol) / Poly (Acrylic Acid) Interpenetrating Networks. Membrane Science, 107(2), 239–248.

Hammond, C., & Tyson, T. (1999). Septic Tank Design and Construction. Water Quality in Georgia, 49(3), 1–4.

Harry, D., & Shelton, S. H. B. L. (2000). Indigenous Peoples ,. Nevada. Retrieved from

Hawaii, (2008). Onsite Wastewater Treatment Survey and Assessment March 2008. (Engineering Solutions, Ed.). Pearl City: Department Of Health.

Health, P., & Protection, H. (2006). S Ewerage S Ystem S Tandard P Ractice. Rhode Island. Dissolved Oxygen Measurement in Wastewater Treatment. Water and Wastewater Industry, (January), 100–104.

Heather Tuner. (2007). The Benefits of Polyethylene vs. Traditional Materials in Water and Wastewater Pipe Applications. North American: Department Water Contamination

Hennry. W. (2010). Septic Tank. Washangton: Broney.M. Rhode Island. Dissolved Oxygen Measurement in Wastewater Treatment. Water and Wastewater Industry, (January), 1–4.

Henry.R. (2004). Natural Resource Management Ministerial Council. (C. Of Australia, Ed.). Australia: Natural Resource Management Ministerial Council.

Hlthman. (2002). Waste Water Treatment 2 2.1. Waste Water, 20(30), 1–18.

Hölttä-Otto, K. (2005). Modular Product Platform Design. Australian Midwifery (Vol. 18).

Homa, P. T. (2006). Wastewater Pumps Amx , and Hydraulic Ranges High Performance in Wastewater Pumping. Ansonia: Department Wastewater Treatment

Homeowners, G. F. (2004). Maintaining Your Septic System, A Guide For Homeowners. Wastewater, 15(4), 1.8.

Huang, Q., Rozelle, S., Wang, J., & Huang, J. (2009). Water Management Institutional Reform: A Representative Look at Northern China. Agricultural Water Management, 96(2), 215–225.

Hughes, G., Chinowsky, P., & Strzepek, K. (2010). The Costs of Adaptation to Climate Change for Water Infrastructure in Oecen Countries. Utilities Policy, 18(3), 142–153.

Hussin, J., Abdul Rahman, I., & Memon, A. (2013). The Way Forward In Sustainable Construction: Issues and Challenges. International Journal of Advances in Applied Sciences, 2(1), 31–42.

Idem. (2008). Wastewater Operator Certification Manual Indiana Department of Environmental. Indiana: Indiana Department of Environmental Management.

Impacts, D., & Location, T. (2011). Section 7 : Septic Tanks. University of Minnesota.

Influence, Z. O. (2013). Guidelines for Building Over, Adjacent to Sydney Water Water and Wastewater Assets, (March), 1–18.

Jabar, I. Laili. (2014). Australian Journal of Basic and Applied Sciences Industrialized Building System Projects : A Survey of Construction Project Manager ' S Competencies in Malaysia, 8(February), 294–300.

Jarosova, B., Blaha, L., Vrana, B., Randak, T., Grabic, R., Giesy, J. P., & Hilscherova, K. (2012). Changes in Concentrations of Hydrophilic Organic Contaminants and of Endocrine-Disrupting Potential Downstream of Small Communities Located Adjacent to Headwaters. Environment International, 45, 22–31.

Je, B., Laine, A., Parsons, S., Stephenson, T., & Judd, S. (2000). Technologies for Domestic Wastewater Recycling. Urban Water, 1(1999), 1–8.

Jordan, M. A., Welsh, D. T., Teasdale, P. R., Catterall, K., & John, R. (2010). A Ferricyanide-Mediated Activated Sludge Bioassay for Fast Determination of the Biochemical Oxygen Demand Of Wastewaters. Water Research, 44(20), 5981–5988.

Jose Carlos. (1998). Electrolytic Treatment of Watewater. Bullein of Electrochemistry, 14(3), 1–3.

Kamar, K., & Hamid, Z. (2011). Industrialized Building System (IBS): Revisiting Issues of Definition and Classification. International Journal , 1(June), 120–132.

Komunikasi, J. (2010). Jurnal Komunikasi, Malaysian Journal of Communication Vol 24: 63-71 63. Malaysian Journal of Communication, 24(3), 63–71.

Legislative, T. H. E., For, R., Criteria, T. H. E., Sewage, for Composition & Sewage (1990). Sewage Treatment Systems. Health Psychology, 28(6), 1–5.

Leroy C. Reid, Jr., P. . (1999). Wastewater Technology Fact Sheet Fine Bubble Aeration. Journal of Environmental Management, 86(1), 63–79.

Lesikar, B. (2007). Septic Tank / Soil Absorption Field. Texas. Water Resources, (02), 250.

Leverenz, H. L., Tchobanoglous, G., & Darby, J. L. (2002). Review Of Technologies For The Onsite Treatment of Wastewater In California. Water Resources, (02), 250.

Li, L., Zhang, S., Li, G., & Zhao, H. (2012). Determination of Chemical Oxygen Demand of Nitrogenous Organic Compounds in Wastewater Using Synergetic Photoelectrocatalytic Oxidation Effect at Tio Nanostructured Electrode. Analytica Chimica Acta, 754, 47–53.

Lidovsky, Z. (2006). Wastewater Treatment and Effluent Reuse. Stockholm: Department Design Innovation

Lohmann, L. (2009). Toward a Different Debate in Environmental Accounting: The Cases of Carbon and Cost–Benefit. Accounting, Organizations and Society, 34(3-4), 499–534.

Lorranie Joubert, George Loomis, David Dow(2005). Choosing A Wastewater Treatment System. Stockholm: Department Design Innovation

Maldonado, J. R. (2010). An Approach to the Patient With Substance Use and Abuse. The Medical Clinics of North America, 94(6), 1169–205, X–I.

Malmqvist, T., & Glaumann, M. (2009). Environmental Efficiency in Residential Buildings, A Simplified Communication Approach. Building and Environment, 44(5), 937–947.

Martin, R. G., & Ames, B. N. (1999). A Method for Determining the Sedimentation Behavior of Enzymes: Application To Protein Mixtures. The Journal of Biological Chemistry, 236(5), 1372–9.

Martinetto, P., Daleo, P., Escapa, M., Alberti, J., Isacch, J. P., Fanjul, E.,Iribarne, O. (2010). High Abundance and Diversity of Consumers Associated With Eutrophic Areas In a Semi-Desert Macrotidal Coastal Ecosystem in Patagonia, Argentina. Estuarine, Coastal and Shelf Science, 88(3), 357–364.

Massoud, M. , Scrimshaw, M. , & Lester, J. (2003). Qualitative Assessment of the Effectiveness of the Mediterranean Action Plan: Wastewater Management in the Mediterranean Region. Ocean & Coastal Management, 46(9-10), 875–899.

Matošić, M., Prstec, I., Jakopović, H. K., & Mijatović, I. (2009). Treatment of Beverage Production Wastewater by Membrane Bioreactor. Desalination, 246(1-3), 285–293.

Mbaiwa, J. E. (2003). The Socio-Economic and Environmental Impacts of Tourism Development on the Okavango Delta, North-Western Botswana. Journal of Arid Environments, 54(2), 447–467.

Mbuligwe, S. E., & Kaseva, M. E. Pollution and Self-Cleansing of An Urban River in A Developing Country: A Case Study in Dar Es Salaam, Tanzania., 36 Environmental Management 328–342 (August 2005). Department of Environmental Engineering, Faculty of Lands and Environmental Engineering, University College of Lands and Architectural Studies, 35176, Dar Es Salaam, Tanzania.

Mcdonald, A T., Chapman, P. J., & Fukasawa, K. (2008). The Microbial Status of Natural Waters in A Protected Wilderness Area. Journal Of Environmental Management, 87(4), 600–8.

Mckinnon, H. W. (2003). Environmental Regulations and Technology Control of Pathogens and Vector Attraction In Sewage Sludge Control of Pathogens and

Vector Attraction. (C. For E. R. Information, Ed.). Cincinnati: National Risk Management Research Laboratory.

Mclean, R. C., Engineering, B. S. C., & Adams, E. E. (2009). Chemically Enhanced Primary Treatment and Sustainable Secondary Treatment Technologies for Use With Imhoff Tanks .Honduras: T. Ecological Engineering.

Medrano, M., Brouwer, J., Mcdonell, V., Mauzey, J., & Samuelsen, S. (2008). Integration of Distributed Generation Systems into Generic Types of Commercial Buildings in California. Energy and Buildings, 40(4), 537–548.

Meinzer, O. E. (1992). Introduction to Groundêwater Contamination. In Water Contamination (pp. 1–13). Washington: Harper & Row.

Michael R. Bloomberg, M. (2005). Wastewater Treatment System Cleaning The Water We Use Protecting .New York City: The Environment New York.

Michigan, S. (2012). Management of Aquatic Plants. Deo, Journal of Environmental Management, 86(1), 63–79.

Migliaccio, K. W., Schaffer, B., Crane, J. H., & Davies, F. S. (2010). Plant Response to Evapotranspiration and Soil Water Sensor Irrigation Scheduling Methods for Papaya Production in South Florida. Agricultural Water Management, 97(10), 1452–1460.

Mihai, P., & Corobceanu, V. (2011). Aggressive Influences of Water from Wastewater Treatment Plants on Reinforced Concrete Members. Universitatea Tehnică, 5(Lxi), 2–9.

Milk, B. (2004). Water Contamination. Bhopal Gas. Journal of Environmental Management, 86(1), 63–79.

Moenne, M. I. (2013). Control Of Bubble-Free Oxygenation With Silicone Tubing During Alcoholic Fermentation. Process Biochemistry, 48(10), 1453–1461.

Mogilner, A., & Odde, D. (2011). Modeling Cellular Processes in 3D. Trends in Cell Biology, 21(12), 692–700.

Mohammed Mahdy, A K. (2008). Risk Factors For Endemic Giardiasis: Highlighting The Possible Association Of Contaminated Water And Food. Transactions Of The Royal Society of Tropical Medicine and Hygiene, 102(5), 465–70.

Mohsen, M. S. (2004). Treatment and Reuse Of Industrial Effluents: Case Study of A Thermal Power Plant. Desalination, 167(1-3), 75–86.

Montagna, B., Pestilli, F., & Carrasco, M. (2009). Author ' S Personal Copy. Vision Research, 49(4), 2–12.

More, O., & Microbes, C (2002). Biological Wastewater Treatment Principles. New Dehli, Department of Wastewater.

Mori, H. (2003). Technology Transfer Manual of Industrial Wastewater Treatment. Green and Sustainable Chemistry (Vol. 3). Japan: Cooperation Center.

Morrison, R. J. (2013). Anthropogenic Biogeochemical Impacts on Coral Reefs in the Pacific Islands,an Overview. Deep Sea Research Part Ii: Topical Studies in Oceanography, 96, 5–12.

Moussavi, G. (2010). Performance of A Pilot Scale Up-Flow Septic Tank for On-Site Decentralized Treatment of Residential Wastewater. Process Safety And Environmental Protection, 88(1), 47–52.

Mucha, Z., & Mikosz, J. (2005). Analysis of Unit Pollution Loads for Small Wastewater Treatment Plants. Warszawa: Warsaw University of Technology.

Mulkerrins, D., Dobson, A & Colleran, E. (2004). Parameters Affecting Biological Phosphate Removal From Wastewaters. Environment International, 30(2), 249–59.

Musa, M. F., Mohammad, M. F., Mahbub, R., & Yusof, M. R. (2014). Enhancing The Quality Of Life By Adopting Sustainable Modular Industrialised Building System (IBS) in the Malaysian Construction Industry. Procedia - Social and Behavioral Sciences, 153, 79–89.

Nasrolah, N., Ibrahim, R., & Mohammad, T. A. (2014). Hazardous Effect of Raw Sewage Disposal From Indigenous Housing Settlement on Natural Water Bodies. Internatinal Jurnal of Curent Reaserch and Academic Review, 1(1), 90–94.

Natasha, D. (2001). Ground Water. In Ground Water Guardian (Pp. 41–86). Alabama: Public Water Systems in Alabama.

Navarro, J. M., Pérez-Pérez, J. G., Romero, P., & Botía, P. (2010). Analysis of the Changes in Quality in Mandarin Fruit, Produced By Deficit Irrigation Treatments. Food Chemistry, 119(4), 1591–1596.

Nicolella, C. (2000). Wastewater Treatment with Particulate Biofilm Reactors. Journal of Biotechnology, 80(1), 1–33.

Nor, M., Azman, A., Ahamad, M. S. S., Hilmi, N. D., Education, V., & Education, S. I. (2012). The Perspective View of Malaysian Industrialized Building. Social and Behavioral Sciences 153, 5(3), 3–13.

Nzaid. (1999). Small Scale Wastewater Treatment Plant Project Report on Project Criteria , Guidelines And Technologies. South Pacific: Department Chemical & Environment

Outreach, P. (2006). A Homeowners Guide : Installing A Septic Tank and Drainfield Nmed Liquid Waste Program Public Outreach and Training. Washington: Research Innovation Center

Pacific, S., Islanders, T. S., & Zealand, N. (2002). Who are Indigenous Peoples Oisika.

Pan, Y. (2010). Study on Simulation Methods of Atrium Building Cooling Load in Hot and Humid Regions. Energy and Buildings, 42(10), 1654–1660.

Park, E., Enander, R., Barnett, S. M., & Lee, C. (2001). Pollution Prevention and Biochemical Oxygen Demand Reduction In A Squid Processing Facility. Journal of Cleaner Production, 9(4), 341–349.

Partnership, N., Housing, R. I., & Review, P. (2013). National Partnership Agreement on Remote Indigenous Housing (Nparih). (Henry.R, Ed.). South Africa: National Partnership. Journal of Environmental Management, 86(1), 100-102

Penha-Lopes, G., Kristensen, E., Flindt, M., Mangion, P., Bouillon, S., & Paula, J. (2010). The Role of Biogenic Structures on The Biogeochemical Functioning of Mangrove Constructed Wetlands Sediments, A Mesocosm Approach. Marine Pollution Bulletin, 60(4), 560–72.

Perera, P., Mailhot, T., Riley, D., & Mandavia, D. (2010). The Rush Exam: Rapid Ultrasound In Shock in the Evaluation of the Critically Lll. Emergency Medicine Clinics Of North America, 28(1), 29–56.

Polyethylene, H., & Systems, P. (2006). High-Density Polyethylene Pipe Systems. South Australia: Department Research and Water Sanitation.

Potable, N., & Applications, W. (2008). Polyethylene Pipe Systems. Radius, 5(3), 2–54.

Poul, D. (2010). Design of Stormwater Tanks Design of Stormwater Tanks. Journal of Environmental Management, 86(1), 63–79.

Practices, B. M., Treatment, B., Treatment, S., & Options, Z. D. (1996). Wastewater Treatment Technologies.

Quayle, W. C., Fattore, A., Zandona, R., Christen, E. W., & Arienzo, M. (2009). Evaluation of Organic Matter Concentration in Winery Wastewater: A Case Study from Australia. Water Science And Technology : A Journal of the International Association on Water Pollution Research, 60(10), 2521–8.

Radić, S., Stipanicev, D., Vujcić, V., Rajcić, M. M., Sirac, S., & Pevalek-Kozlina, B. (2010). The Evaluation of Surface and Wastewater Genotoxicity Using the Allium Cepa Test. The Science of the Total Environment, 408(5), 1228–33.

Rahinah Ibrahim. (2015). Need More Info Like Us At IBS : A Critical Success Factor of at Expo Milano 2015. IBS Digest, 1(2), 28–20.

Ramalho, R. (2012). Theory and Practice of Aeration in Wastewater Treatment. Introduction to Wastewater Treatment Processes, Journal of Environmental Management, 86(1), 63–79.

Reinemann. (1987). A Theoretical and Experimental Study of Airlift Pumping and Aeration With Reference to Aquacultural Applications. South Australia: Department Research and Water Sanitation.

Richmond, C. A M., & Ross, N. A. (2009). The Determinants of First Nation and Inuit Health: A Critical Population Health Approach. Health & Place, 15(2), 403–11.

Rohde, C. A. (1976). Composite Sampling. Biometrics, 32(3), 273–282.

Said, S. (1996). Paper 1 : The Grammar of Traditional Malay Long-Roof Type Houses. In the Grammar of Traditional Malay Long-Roof Type Houses (Pp. 9–21). Johor: Faculty of Built Environment, Universiti Teknologi Malaysia.

Scala, A. (2000). Free Energy Surface of Supercooled Water. Physical Review. E, Statistical Physics, Plasmas, Fluids, And Related Interdisciplinary Topics, 62(6 Pt A), 8016–20.

Schipper, L. A. (2010). Denitrifying Bioreactors, An Approach for Reducing Nitrate Loads To Receiving Waters. Ecological Engineering, 36(11), 1532–1543.

Scott, D. (1995). Waste Control Systems. South Australia: National Library of Australia.

Sepúlveda, J., Valdespino, J. L., & García-García, L. (2006). Cholera In Mexico: The Paradoxical Benefits of the Last Pandemic. International Journal of Infectious Diseases : Ijid : Official Publication of the International Society for Infectious Diseases, 10(1), 4–13.

Shaari, M. N. G., & Law. (2014). Penerbit Universiti Sains Malaysia, 2014. Kajian Malaysia, 32(2), 1–21.

Singh, K. P., Mohan, D., Sinha, S., & Dalwani, R. (2004). Impact Assessment of Treated/Untreated Wastewater Toxicants Discharged By Sewage Treatment Plants on Health, Agricultural, and Environmental Quality in the Wastewater Disposal Area. Chemosphere, 55(2), 227–255.

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.

Solomon, S. (2011). Global Water Issue. Bureau of International Information Programs, United States Department Of State, 1–152.

SPAN .(2009). Guidelines. Cyberjaya: Suruhanjaya Perkhidmatan Air Negara.

Spada, G. (2008). Alma, A Fortran Program for Computing the Viscoelastic Love Numbers of A Spherically Symmetric Planet. Computers & Geosciences, 34(6), 667–687.

Spencer, P., Sc, D. B., & Ph, D. (2005). The Biological Basis of Wastewater Treatment. (J. Main, Ed.). Strathkelvin: Peter Spencer Davies, A Critical Population Health Approach. Health & Place, 15(2), 403–11.

Sperling, M. Von, Augusto, C., & Chernicharo, D. L. (2005). Treatment in Warm. Biologicalwastewater, 1(25), 1–24.

Stevik, T. K., Aa, K., Ausland, G., & Hanssen, J. F. (2004). Retention And Removal of Pathogenic Bacteria In Wastewater Percolating Through Porous Media: A Review. Water Research, 38(6), 1355–67.

Struthers, R., & Eschiti, V. S. (2005). Being Healed By an Indigenous Traditional Healer: Sacred Healing Stories of Native Americans. Part Ii. Complementary Therapies in Clinical Practice, 11(2), 78–86.

Tappero, J. W., & Tauxe, R. V. (2011). Lessons Learned During Public Health Response to Cholera Epidemic In Haiti and the Dominican Republic. Emerging Infectious Diseases, 17(11), 2087–93.

Tchobanoglous, G., Burton, F., & Stensel, H. D. (1991). Wastewater Engineering: An Overview. Wastewater Engineering Treatment And Reuse, 14(2), 1–24.

Thanoon, W. A. (2003). The Essential Characteristics of Industrialised Building System. International Conference on Industrialised Building Systems, Kuala Lumpur, Malaysia, (1999), 10–11.

Thierfelder, C., & Wall, P. C. (2009). Author's Personal Copy Effects of Conservation Agriculture Techniques on Infiltration and Soil Water Content in Zambia and Zimbabwe. Soil & Tillage, 105(2), 8–12.

Todd, R. W., Cole, N. A., Clark, R. N., Flesch, T. K., Harper, L. A., & Baek, B. H. (2008). Ammonia Emissions from a Beef Cattle Feedyard on the Southern High Plains. Atmospheric Environment, 42(28), 6797–6805.

Travis, M. J., Weisbrod, N., Gross, A., & Ben-Gurion, M. (2008). Accumulation of Oil and Grease In Soils Irrigated With Greywater And Their Potential Role In Soil Water Repellency. Cience of the Totale Environment, 94(3), 3–9.

Trittin, J. (2005). Federal Ministry for the Environment , Nature Conservation and Nuclear Safety , Germany Promulgation of the New Version of the Ordinance on Requirements for the Discharge of Waste Water into Waters on the Basis of Article of The Sixth Ordinance for Amen. for the Environment, Nature Conservation and Nuclear Safety, 5(June 2004), 1–121.

Tyagi, V. V., Kaushik, S. C., Tyagi, S. K., & Akiyama, T. (2011). Development of Phase Change Materials Based Microencapsulated Technology for Buildings: A Review. Renewable and Sustainable Energy Reviews, 15(2), 1373–1391.

Vieno, N., Tuhkanen, T., & Kronberg, L. (2007). Elimination of Pharmaceuticals in Sewage Treatment Plants in Finland. Water Research, 41(5), 1001–1012.

Water technology (2009). Wastewater Treatment, Design of Stormwater Tanks Design of Stormwater Tanks. Journal of Environmental Management, 86(1), 63–79.

Walter, W. G. (1961). Standard Methods for the Examination of Water and Wastewater (11th Ed.). American Journal of Public Health and the Nations Health, 51(6), 940.

Wang, X. (2007). Classification of Contaminants and Treatability Evaluation of Domestic Wastewater. Frontiers of Environmental Science & Engineering in China, 1(1), 57–62.

Wang, Y., & Nnaji, B. O. (2001). Functionality-Based Modular Design for Mechanical Product Customization Over the Internet. Journal of Design and Manufacturing Automation, 1(1-2), 107–121.

Wang, Y., Teng, E., Liu, T., Lv, Y., Jin, X., Giesy, J. P., & Hollert, H. (2014). A National Pilot Scheme for Monitoring and Assessment of Ecological Integrity of Surface Waters in China. Environmental Development, 10(1), 104–107.

Wang, Z., Xue, M., Huang, K., & Liu, Z. (2010). Textile Dyeing Wastewater Treatment. China.

Waste, L. (1999). January 1999 Edition. New York: Pweagle.

Whittington, D., Sur, D., Cook, J., Chatterjee, S., Maskery, B., Lahiri, M., Bhattacharya, S. K. (2009). Rethinking Cholera and Typhoid Vaccination Policies for the Poor: Private Demand in Kolkata, India. World Development, 37(2), 399–409.

Wiliam, F. (2010). Specifications for Sewage Disposal. Yukon: Environmental Health Services.

William. (1997). Domestic Wastewater Facilities Manual a Guide for the Preparation of Applications , Reports and Plans. Westmoreland: Regional Water Quality Manager.

Winkler, M. (1997). Optimal Nutrient Ratios for Wastewater Treatment Nutrients in Activated Sludge. Casablanca: Sanitation Department.

Wong, H., Liu, D.-P., Liu, S., Chung, Y.-C., & Shimada, T. (2002). Characterization of Vibrio Cholerae O139 Isolated in Taiwan. Food Microbiology, 19(6), 653–661.

Wurts, W. A. (2011). Wastewater Treatment Best Practices. New Dehli: Wiley

Wurts, W. A., Mcneill, S. G., & Overhults, D. G. (2012). Performance and Design Characteristics of Airlift Pumps for Field Applications (Vol. 25). North American.

Yuan, L. J. (2002). The Traditional Malay House. Penang: Portal Rasmi Kerajaan Negeri Pulau Pinang.

Yuan, Z., Ramaswami, B., Casaletto, D., Falke, S., Angenent, L. T., & Giammar, D. E. (2007). Evaluation of Chemical Indicators for Tracking and Apportionment of Phosphorus Sources to Table Rock Lake in Southwest Missouri, USA. Water Research, 41(7), 1525–33.

Yue, B., Chen, T.-B., Gao, D., Zheng, G.-D., Liu, B., & Lee, D.-J. (2008). Pile Settlement and Volume Reduction Measurement During Forced-Aeration Static Composting. Bioresource Technology, 99(16), 7450–7.