RAINWATER HARVESTING SYSTEM FOR SURAU AN-NUR, TAMAN PEKAKA, NIBONG TEBAL, PENANG

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SCHOOL OF CIVIL ENGINEERING
UNIVERSITI SAINS MALAYSIA
2018

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By

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This dissertation is submitted to

UNIVERSITI SAINS MALAYSIA

As partial fulfilment of requirement for the degree of

BACHELOR OF ENGINEERING (HONS.)
(CIVIL ENGINEERING)

School of Civil Engineering,
Universiti Sains Malaysia

June 2018

SCHOOL OF CIVIL ENGINEERING
ACADEMIC SESSION 2017/2018

FINAL YEAR PROJECT EAA492/6
DISSERTATION ENDORSEMENT FORM

Title: RAINWATER HARVESTING SYSTEM FOR SURAU AN-NUR TAMAN PEKAKA, NIBONG TEBAL, PENANG

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ACKNOWLEDGEMENT

I would like to acknowledge the following people for their contribution to this research project. First and foremost, it is a genuine pleasure to express my deep sense of thanks and gratitude to my supervisor, Assc. Prof. Dr. Mohd Remy Rozainy bin Mohd Arif Zainol for his advice, guidance and encouragement given for completion of this final year project. I am so appreciative of your advice on both my research as well as on my career also experience from your work with obese people. Thank you for patience, enthusiasm and moral support throughout the entire research project and development of this thesis.

I would like to thank the coordinator of Final Year Project (EAA 492), Assc. Prof. Dr. Norazura Muhammad Bunnori. Thank you for your guidance throughout my research. I also like to thank all the staff within School of Civil Engineering that have help me, especially the staff in environmental laboratory that have guide me during my laboratory work. Your helps and co-operation is truly appreciated.

A special thanks to all of the staff of Surau An- Nur. Thank you for letting me do this research at your place. You all have very kind to me.

Finally, I would like to express my appreciation to my family for their love and support. I would also like to thank all of my friend who helped and supported me to complete this research. Thank you for your constant source of strength and belief in me. With that, thank you.

ABSTRAK

Penggunaan air yang mampan boleh mengekalkan keseimbangan permintaan dan bekalannya. Sistem penuaian air hujan (SPAH) adalah kaedah pengurusan terbaik dalam amalan pengurusan air yang berkesan di Malaysia. SPAH adalah kaedah paling tradisional dan mampan kerana system ini bertujuan untuk melambatkan aliran larian permukaan dan mempromosikan penggunaan kecekapan air. Kajian SPAH dilakukan di Surau An-Nur. Pengumpulan air hujan telah dilakukan di antara Oktober 2017 dan April 2018. Bagi kajian ini, parameter air hujan telah dianalisis dari segi fizikal, kimia dan biologi. Dari ujian, kekeruhan adalah 3-7 mg/L, pH ialah 5.13-6.44, oksigen larut adalah 5.76-7.73 mg/L, kandungan besi adalah 0-0.011 mg/L, kandungan tembaga 0-0.012 mg/L, jumlah coliform adalah 0-0.13 MPN dan jumlah pepejal terampai adalah 3-7 mg/L. Berdasarkan hasil yang diperoleh, ia menunjukkan air hujan sesuai untuk digunakan untuk wudhuk. Reka bentuk telah dilakukan menggunakan Perisian Tangki Nahrim dan kos pemasangan telah dikira. Saiz tangki ialah 1.75 m^3 dan jumlah kos pemasangan sistem penuaian air hujan ialah RM 1571.00.

ABSTRACT

Sustainable use of water could maintain a balance of its demand and supply. Rainwater harvesting system is a best management method in effective water management practice in Malaysia. RHW is the most traditional and sustainable method because this system aims to slow down the flow of surface runoff and promote efficiency use of water. The study of RHW was conducted at Surau An-Nur. The rainwater collection had been done in between October 2017 and April 2018. For this study, the parameters of rainwater have been analysed for the physical, chemical and biological. From the test, turbidity is 3-7 mg/L, pH is 5.13-6.44, dissolve oxygen is 5.76-7.73 mg/L, iron content is 0-0.011 mg/L, copper content is 0-0.012 mg/L, total coliform is 0-1.3 MPN and total suspended solids is 3-7 mg/L. Based on the result obtained, it indicates the rainwater is suitable to be used for ablution. The design had been done using Tangki Nahrim Software and installation cost had been calculated. The size of the tank is 1.75 m^3 and the total cost of the installation rainwater harvesting system is RM 1571.00.

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CHAPTER 1

INTRODUCTION

1.1 General

By 2025, about 1.8 billion people are expected to experience water scarcity, while two-thirds of the population will experince water stress (United Nations, 2014). As populations increase, so does demand for adequate supplies of clean water. Water is one of the most important substance and essential component for all living organisms in daily life (Afshar, 2015).

For tropical rainforest climate country like Malaysia, rainwater is selected as an alternative to reduce the dependency towards existing water resources because it is natural water that falls from the sky which is precipitate througout the year. Malaysia also received large quantities of the rainfall. Typically, the average rainfall is around 2400 mm in Peninsular Malaysia, 3830 mm in Sabah and 2360 mm in Sarawak throughout the year (Asrah & Abidin, n.d.).

Rainwater harvesting could be the most suitable solution to be included in the urban water management system because it is an effective option not only to recharge the groundwater aquifer but also to provide adequate storage of water for future use (Rahman et al., 2014). Rainwater harvesting is the method by which rainwater that falls upon a roof surface is collected and routed to a storage facility for later use (Debusk & Hunt, 2012).

1.2 Problem Statement

The increasing number of people use to pray at Surau An-Nur, the demand water use for ablution increase. Rainwater harvesting is an alternative to supply water and it will reduce the demand of water supply. So, it will reduce the amount of water bill.

The public water supply use for suitable usage that may lead to wastage of the public water supply can be used for more suitable purpose. For example, ablutions and gardening.

During heavy rainfall, the rainwater from the runoff will flow directly into drain and cause flash flood to occur. When the rainwater rapidly move and fully occupied the drain, this water cannot flow away and hence creating the flash flood.

1.3 Objectives

The objectives in this study are:

1. To determine quality and quantity of rainwater at Surau An-Nur
2. To design rainwater harvesting for Surau An-Nur
3. To determine the installation cost of rainwater harvesting system

1.4 Scope of Work

The sample rainwater should be at the proposed catchment area that the rainwater fall on the roof gutter in Surau An-Nur. There are three parameter that need to be checked which is physical, chemical and biological properties. For physical properties, the test involved for turbidity by using turbidity meter and total suspended solid (TSS). For chemical properties, the test conducted are pH test using pH meter, iron content and copper content test by ICP machine and dissolved oxygen (DO) using DO meter. For biological parameter test only involved for total coliform. All the rainfall data that need to be used for analysis were obtained from Jabatan Pengairan dan Saliran (JPS). From the analysis, average accumulated rainfall annually will be obtained. The rainfall data will insert to Tangki Nahrim Software to design the suitable tank for rainwater harvesting system. The tank will be design for three different size of tank. Lastly, after select the most suitable size of the storage tank, the cost installation of this rainwater harvesting system will be calculated.

1.5 Benefits of Project

The outcomes of the project will provide some benefits in understanding the concept of rainwater harvesting system. The benefits are:

1. Reduce the demand of public water supply for Surau An-Nur, hence reducing the water bill. By utilizing the rainwater for purposes such as ablution and plant watering, the usage of public water supply will be reduced. This will lead to a reduction to the amount of monthly water bills.
2. Provide high quality of soft water with low mineral content. Rainwater is known as water with lowest mineral content because it is originated from cloud. So it will provide water with low mineral content compared to public water supply that was treated from river and dam.
3. As an alternative water supply, in case of emergency where Surau An-Nur doesn't have a water supply. Rainwater will be stored in different tank. This water will not mix with the public water supply tank. So, if the public tank is empty by some problem, people can use rainwater for their suitable purposes.
4. Reduce the risk of flooding, some studies suggest rainwater is stored in tanks provide a local storm water attenuation feature, as rainwater is stored in tanks and

released over a period of time, rather than entering storm sewer system as a peak load.

1.6 Benefits of Project

Chapter 1: Introduction – General description of study that includes problem statement, objectives to achieve and scope of work to be carried out.

Chapter 2: Literature review – The content of this chapter is discussing about water issues, water quality and health risk in Malaysia, rainwater harvesting system, advantages and disadvantages of this study, maintenance of the rainwater harvesting system and challenges of rainwater harvesting.

Chapter 3: Methodology – Explaining all the test conducted for determine the quality of rainwater such as pH, dissolved oxygen (DO), turbidity, total suspended solid (TSS), total coliform, iron content and copper content. This chapter consists of introduction of the study area, description to the sample analysis and rainfall data collection, Tangki Nahrim software and Autocad software.

Chapter 4: Results and Discussion – The results of the study are discussed in this chapter including rainwater quality analysis and comparison with Interim National Water Quality Standards and Drinking Water Quality Standards for Malaysia and rainwater harvesting cost.

Chapter 5: Conclusion and Recommendation – This chapter concludes the findings in this study and provides suggestion for the next study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Malaysia receives rainfall from 2000 mm to 4000 mm annually where it is greatly influenced by two monsoon periods in November to March and May to September. Malaysia's water consumption is alarmingly high and increasing every year. Water consumption per capita per day increase about 7.6 litres per year. This increase in water consumption is not matched by an increase in water reserves. Malaysia's water reserves per capita per day is declining at a rate of 5.8 litres per year. At this rate, Malaysia would be left with nearly no water reserves by 2025 (Afshar, 2015).

In 2011, the Malaysia government imposed residential building (bungalow and semi-detached) and all types of building with roof area equal or more than 100 m^2 in all states of Peninsular Malaysia and the Federal Territories to install rainwater harvesting system through the amendment of the Uniform Building By-Laws 1984, which was approved by the National Council of Local Government (Lee et al., 2016).

Started in February 2014, rainwater harvesting system have been implemented throughout Peninsular Malaysia, including Federal Territories to standardize the requirement for non-potable water supply system. Rainwater is collected for general washing and gardening purposes, but the common use of rainwater in a building is for toilet flushing whereby the rainwater cistern is connected to the water closet fitting to minimize the use of treated water for non-potable use (Lee et al., 2016).

2.2 Water Issues in Malaysia

In Malaysia, the source of water for daily use comes from treated water. Due to the growth of population and expansion of industrial and agricultural, the demand for water has increased manifold. The problems arise when water is not sufficient to meet the demand or is polluted. Vast development in various sectors resulted in such impacts on high demand of clean water in some areas. It changes the availability, quantity and quality of the water resources, which will have an impact on the whole cycle of water supply. Nowadays, Malaysia and other Southeast Asian countries receive very high intensities of rainfall during monsoon season. In December 2014, the villagers in Kelantan and some parts of Terengganu faces water supply disruption after a water supply plant has affected by the devastating flood. Tube wells were then built to supply clean water (Ayob & Rahmat, 2017).

Another event that is often associated with the shortage of water is El Nino. El Nino is a natural phenomenon which occurs in Pacific Ocean when warm waters of the western coast of South America replace the colder nutrient rich waters and cause impacts on the weather patterns such an increasing the temperature between 0.5℃ and 2℃ and reducing the amount of rainfall. The country experienced dry and warm conditions from June to August which had affected the water resources in some areas (Ayob & Rahmat, 2017).

2.3 Rainwater Harvesting System

Rainwater harvesting is a multipurpose way of supplying usable water to consumers during crisis periods, recharging the groundwater and finally reducing the runoff and water logging during the season of heavy rainfall. During the rainy season, an individual can collect water on rooftops and manage it on his own. Reserved rainwater on rooftop can be used for self-purposes or domestic use (Rahman et al., 2014).

Rainwater harvesting is the method by which rainwater that falls upon a roof surface is collected and routed to a storage facility for later use. Rainwater harvesting system are a compilation of many components and processes, including catchment surface, conveyance system, pre-storage filtration, storage container, pump, post-storage filtration/treatment and post storage distribution system.

A simple system usually consists of a catchment area, and a means of distribution system, which operates by gravity. Water are collected on roofs, paved areas or the soil surface. Gravity moves the water to where it can be used. In some cases, small containers are used to hold water for later use. A catchment area is any area from which water can be harvested. The best catchments have hard, smooth surface, such as concrete or metal roofing material. The quantity of water harvested depends on the size, surface texture and slope of the catchment area. Distribution systems direct water flow and can be very simple or complex (Afshar, 2015).

2.4 Basic Component of Rainwater Harvesting System

There are five basic components of rainwater harvesting system:

2.4.1 Catchment surface

The quantity of rainwater that can be captured from a catchment surface such as a roof is a function of its size and texture. Roofs that are made of textured or porous material, such as clay tile, will retain more water compared to smoother materials such as metal. The catchment materials will also control the type and potential for leaching of small amount of toxins.

2.4.2 Gutter and downspouts

Gutter and downspouts for rainwater harvesting systems are essentially no different than conventional gutter and downspouts. The only added consideration for a rainwater harvesting system is the number of screens and first-flush diverters that will be needed, since each downspout should have its own.

2.4.3 First flush

The first "flush" of rainwater will contain material that has collected on the catchment surface since the last rainfall, such as dust, pollen, leaves, insects, bird feces and other residues. A first-flush diverter is usually a stand pipe, which allows the debris – containing water to be diverted from the entering the cistern. The suggested volumes ranges from 10 to 50 gallons for every 1000 ft^2 of catchment surface; this number of dry days since the last rainfall and the intended use of the water. Each downspout will require its own first-flush diverter and the diverter should be sized according to the portion of the catchment that contribute to the downspout.

2.4.4 Cisterns

The cistern or storage tank, stores the collected rainwater for later use and is usually the most expensive component of the system. Cisterns are constructed from many materials such as fibreglass, polypropylene, concrete or metal. However, they are best made of non-reactive material or if not, should be lined.

They should also opaque, to inhibit algal growth; cisterns constructed from translucent material are often painted prior to use. Any vents should be screened to discourage mosquito breeding. Cisterns should be periodically cleaned to remove any accumulated sediments and discourage algal growth. Cisterns can be located above or belowground; belowground cisterns should be adequately reinforced.

2.4.5 Delivery system

Depending on the location of the cistern and the intended use of the water, a pump and/or pressure tank may be installed to achieve the desired water pressure. Pump and pressure tank combination will also require a one-way check valve between the pump and cistern to prevent backflow and loss of pressure. Alternately, an on-demand pump can be used, eliminating the need (and space) for a pressure tank (Systems & Rainwater, 2014).

In certain case where collected rainwater is for potable usage, purification involving filtering, distillation and disinfection are the optional component in rainwater harvesting system. The harvesting process from rainfall up to end user is conceptually shown in Figure 2.1 below.

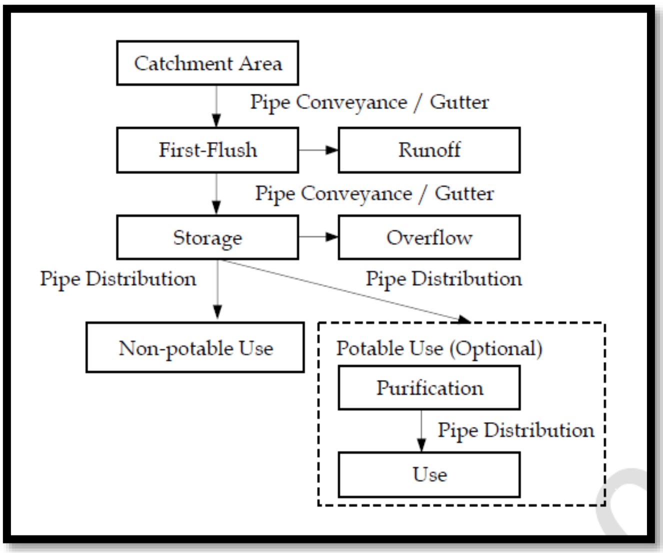

Figure 2.1: Rainwater harvesting process (Source : MSMA, 2012)

2.5 Advantages and Disadvantages of Rainwater Harvesting System

The rainwater harvesting system has its own pros and cons. The advantages and disadvantages of rainwater harvesting system are listed below (Khoury-nolde, n.d.):

2.5.1 Advantages of rainwater harvesting

i. Rainwater is a relatively clean and free source of water

ii. Rainwater harvesting provides source of water at the point where it is needed

iii. It is owner-operated and managed

iv. It is socially acceptable and environmentally responsible

v. It promotes self-sufficiency and conserves water resources

vi. Rainwater is friendly to landscape plants and gardens

vii. It reduces stormwater runoff and non-point source pollution

viii. It uses simple, flexible technologies that easy to maintain

ix. Provides safe water for human consumption after proper treatment

x. Low running costs

xi. Construction, operation and maintenance are not labour-intensive

2.5.2 Disadvantages of rainwater harvesting

i. Rainwater is not a reliable water source in times of dry periods or prolonged drought
ii. Low storage capacity will limit rainwater harvesting, whereas, increasing the storage capacity will add to the construction and operating costs making the technology less economically feasible
iii. Possible contamination of the rainwater with animal wastes and organic matter which may result in health risks if rainwater is not treated prior to consumption as a drinking water source
iv. Leakage from cisterns can cause the deterioration of load-bearing slopes
v. Cisterns and storage tanks can be unsafe for small children if proper access protection is not provided

2.6 Maintenance of Rainwater Harvesting System

Maintenance of the rainwater utilization equipment is very important for collection, storage and use of clean water to reduce likelihood of contamination. The following areas should be carried out during the periodic cleaning of the system (Local Government Department, n.d.).

2.6.1 Catchment area

Trash and animal excreta in catchment area including roof must be cleaned regularly to prevent downpipe clogging.

2.6.2 Sedimentation tank

In the off-rainy season, sedimentation tanks should be cleaned completely. For ground level rainwater tanks, sediments are removed from the drain pipe at the bottom of the tank.

2.6.3 Filter/Screen

Sand and trash caught by filters/screen should be removed and cleaned regularly

2.6.4 Rainwater storage tank

Inside check should be conducted when sediment is removed. The inside should be cleaned. Through maintenance of the catchment areas, sedimentation tank/filter/screen can reduce the frequency of inside cleaning.

2.6.5 Rainwater supply equipment

Make sure the mechanical devices such as pumps are working normally by checking at least every three month. Other devices should undergo a check about every six month and maintained in the same way as treated water equipment.

2.7 Challenges of Rainwater Harvesting

Five interconnected challenges have been generally identified based on analysis namely environmental, policy, economic, social and technical aspects. These challenges need to be addressed in the planning, funding, construction, operation and maintenance, in order to consolidate rainwater harvesting system as an alternative water resources (Lee et al., 2016).

2.7.1 Environment

The intergovernmental Panel on Climate Change (IPCC) Fifth Assessment (IPCC, 2013) reported that it is virtually certain there will be warmer and fewer cold days and nights over most land in 21st century. Peninsular Malaysia is projected to have lower average precipitation during December through February, which used to be relatively high in precipitation. Therefore, the changes in rainfall pattern due to climate change need to be taken into account for designing rainwater harvesting system.

2.7.2 Policy

Despite several guidelines have been launched by the Malaysian government since 1999, RWH has yet to gain much public popularity. The most encouraging development was introduces by the government to take RWH mandatory in March 27,2006.

2.7.3 Economics

The cost of installing a RWH system in Malaysia is estimated between USD 400-USD3000. The payback time could take years and such a cost-benefit trade-off makes it uneconomical to install RWH system in view of its low return of investment. The scaling-down of RWH system to a smaller unit could make the installation cost cheaper and hence make the RWH economical.

2.7.4 Social

Public perception has given the impression that it is unnecessary to harvest rainwater as their alternative water resource. RWH is self-sufficient and able to reduce the dependence on domestic water supply by developing an appreciation for water resources among the residents in the urban area.

2.7.5 Technical

58% of water supply can be provided by RWH and 41% must be supplied by the water utility (Hashim, 2013). The optimization of the RWH system design is crucial to meet the supply and demand network at optimal reliability. There are many technical parameters to be taken into account for RWH, namely rainfall characteristics, catchment area (roof area), cistern storage size, rainwater demand (for non-potable purposes) and overall water use pattern. RWH system could be ineffective if other technical parameters such as first flush volume and losses on the roof through evaporation and splashing have been overlooked. Therefore, innovative technical solution such as rainwater recycling is needed to increase the yield of RWH.

2.8 Water Quality and Health Risk

Rainwater is relatively free from impurities such as wind-blown, dirt, leaves, faecal droppings from animals and insect by rain from the atmosphere. Rainwater may deteriorate during harvesting, storage and household use. Good hygiene of rainwater harvesting system with clean catchments and storage tanks can offer drinking-water with very low health risk and poorly designed and managed system can expose to high health risks.

Rainwater is slightly acidic and very low in dissolved minerals but it can dissolve heavy metals and other impurities from materials of the catchment, storage tanks or from atmospheric pollution. Chemical concentration in rainwater are within acceptable limits.

Rainwater lacks minerals, but some minerals such as calcium, magnesium, iron and fluoride, in appropriate concentration are considered very essential for health. The implication of using rainwater as the primary source of drinking-water should be considered. The absence of minerals also means that rainwater has a particular taste or lack of taste that may not acceptable to people used to drinking other mineral-rich natural waters.

E.coli (or alternatively, thermotolerants coliforms) indicated microbiological contamination of collected rainwater is quite common, particularly in samples collected shortly after rainfall. Pathogens such as *Crysptosporidium, Giardia, Campylobacter, Vibrio, Salmonella, Shigella and Pseudomans* have also been detected in rainwater. However, the occurance of pathogens is generally lower in rainwater and the presence of non-bacterial pathogens can be minimized. Generally, first flush of rainwater will have higher microbial concentration and the level of contamination reduces as the rain continues. In rainy seasons, when catchment are frequently washed with fresh rainwater, microbial contamination will reduce. Storage tanks can present breeding sites for mosquitoes, including species that transmit dengue virus (Rijsberman, 1998).

2.8.1 Interim National Water Quality Standard

The Interim National Water Quality Standard (INWQS) is a set of standards derived based on beneficial uses of water, such as domestic water supply, fisheries and aquatic propagation, livestock drinking, recreational and agricultural use (DOE 1985). The INWQS defined six classes (I, IIA, IIB, III, IV and V) with class I being the best water quality and class V being the worst. More details of INWQS are shown in Appendix A.

2.8.2 Drinking Water Quality Standard

Drinking Water Quality Standard undertook by Engineering Services Division, Minister of Health Malaysia based on new specification information as well as new chemicals found in drinking water as available in the WHO Guidelines for

Drinking Water. The details of the drinking water quality standard are shown in Appendix B.

2.9 Summary

This chapter covers study about rainwater harvesting system. All basic component that should be understood before methodology can be done. The quality of rainwater is an important element in rainwater harvesting system. We can compare the quality of rainwater with INWQS and drinking water quality standard. Hence, we can know the suitable purposes of rainwater if the rainwater harvesting is applied.

CHAPTER 3

METHODOLOGY

3.1 Introduction

After conducting the literature study, the study was divided into two stage. The first stage is to collect the rainwater at Surau An-Nur. The rainwater at the site should be obtained in order to do laboratory test to know the parameters of rainwater at the site. The rainwater will be collected passed through the roof gutter to investigate whether the roof gutter material will have an effect on the quality of rainwater.

The laboratory test is divided into three properties which are physical, chemical and biological. To ensure the quality, the tests on samples have been conducted the same day when the samples had been collected. After obtained the data for the properties of rainwater, the second stage is to collect the rainfall per year. The monthly water demand cost and size of catchment area also will be obtained. The collected data will be used to analyse the reliability of rainwater harvesting system and it will prove the objective of the study.

3.2 Framework of Study

Figure 3.1 below show the framework of the study for this research project. Firstly, the rainfall data and rainwater sample at site must be obtained. The rainwater sample will be used to do the laboratory test while the rainfall data at Pejabat JPS Simpang 3, Parit Buntar will be used to analyse and design the rainwater harvesting system. The Tangki Nahrim software were used to analyse the reliability of the rainwater harvesting based on chosen tank size. Finally, the rainwater harvesting system was designed and the installation cost of the system was obtained.

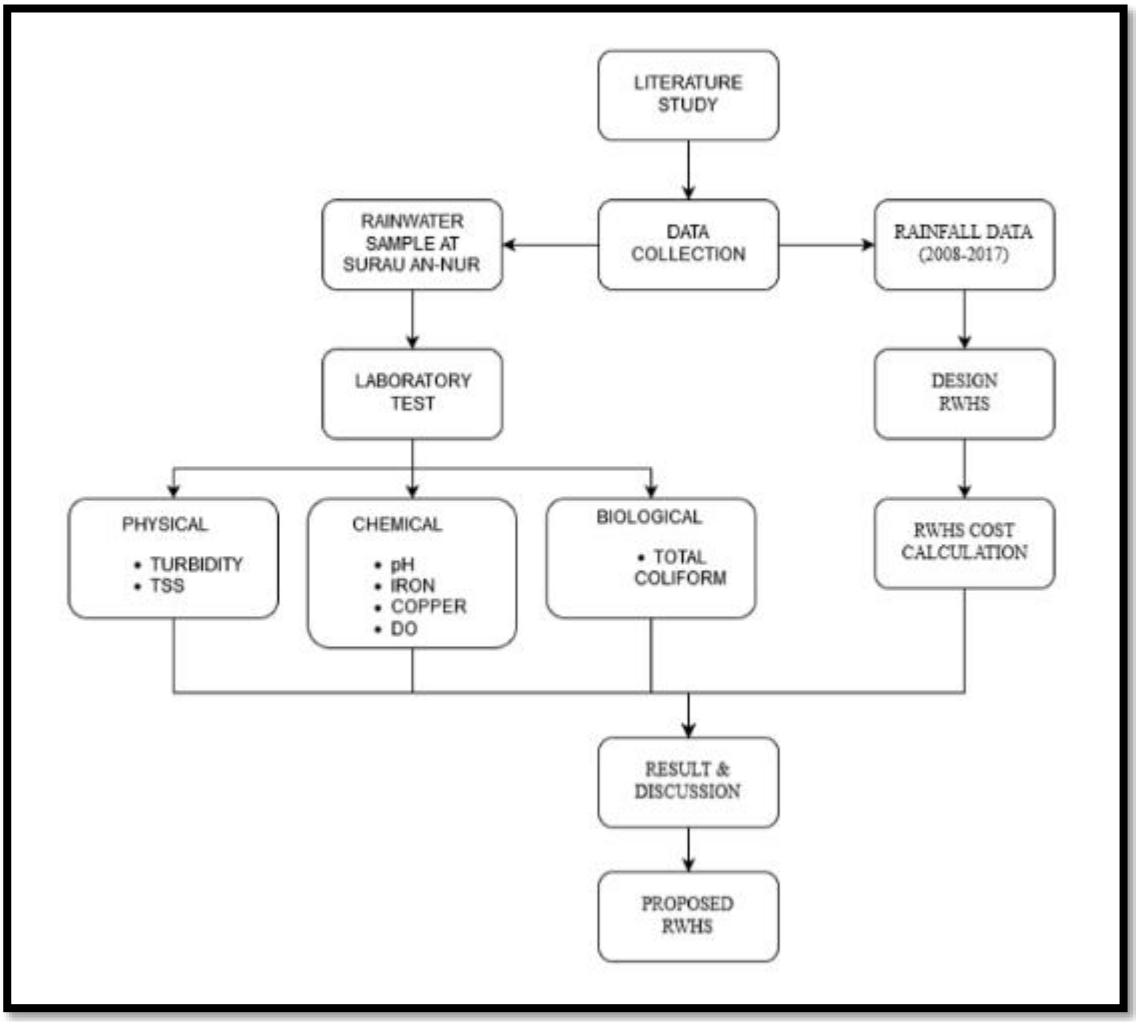

Figure 3.1: Flow chart of the research methodology

3.3 Study Area

The site for this study at Surau An-Nur, Taman Pekaka in Nibong Tebal, Penang. The area have several buildings with different uses such as the school, surau and mahad. It lies on latitude 5°8’27.388” North and longitude 100°29’23.387” East. The study of rainwater harvesting system for non-potable use was conducted at area of Surau An-Nur that can be used for ablutions. Roof gutter will become the catchment area and its wil transport the rainwater to the storage tank. From the storage tank, its will distribute to the nearest (new) pipe line that will be built.

Figure 3.2: Location of the site

Figure 3.3: Location of Sekolah Rendah Agama An-Najah

Figure 3.4: Location of Surau An-Nur

3.4 Data Analysis

The sample rainwater has tested to obtain the parameter of the rainwater and the test has conducted on the same day of sample collection to ensure a better quality results. The water quality was compared with suitability of non-potable uses such as toilet flushing, landscaping, washing and irrigation. Furthermore, it also will be compared with Malaysia Drinking Water Quality Standard.

3.5 Parameter for Water Quality

The sample will be test for three properties are physical properties, chemical properties and biological properties. For physical properties, the parameter involved are turbidity and total suspended solid. For chemical properties, the parameter will obtained are dissolved oxygen, pH, iron content and copper content. The biological properties, only total coliform will obtained.

3.5.1 Physical properties

The two physical properties that need to be tested are turbidity and total suspended solid to indicate the rainwater whether it is polluted or not.

3.5.1.1. Turbidity

Turbidity is a unit of measurement quantifying the degree to which light travelling through a water column is scattered by the suspended solid (including algae) and inorganic particles. The scattering of light will be increased with a greater suspended load. Turbidity value obtain by using turbidity meter. Turbidity is commonly measured in Nephelometric Turbidity Units (NTU) of Jacson Turbidity Unit (JTU).

Figure 3.5: Turbidity meter

3.5.1.2. Total Suspended Solid

Total suspended solids are solids in water that are not dissolved and can be trapped by a filter. Higher concentration of suspended solids means that the water quality is not good. DR 2800 Spechtometer is used to obtain the value of TSS in mg/L.

Figure 3.6: DR 2800 Spectrometer

3.5.2 Chemical properties

A chemical property is any of a material's properties that become evident during a chemical reaction; that is, any quality that can be established only by changing a substance's chemical. The parameter that need to obtain are dissolved oxygen, pH and heavy metal.

3.5.2.1. Dissolved oxygen

The dissolved oxygen level can be an indication of how polluted the water is and how well the water can support aquatic plant and animal life. The DO meter has used to obtain the value. Higher DO levels (reading) indicate better quality.

Figure 3.7: DO meter

3.5.2.2. pH

The alkanlinity of water is a measure of its capacity to neutralize acids. The alkalinity of natural water is due primarily to the salts of weak acids, although water string bases may also contribute. The pH of 7 is considered to be neutral. Substances with pH of less than 7 are acidic while pH more than 7 are alkaline. The pH value was obtained using pH meter.

Figure 3.8: pH meter

3.5.2.3. Iron and Copper

ICP-OES (Inductively Coupled Plasma – Optical Emission Spectrometry) is a technique in which the composition of elements in (mostly-dissolved) samples can be determined using plasma and spectrometer. It can be used for determination of metals more than 20 type of heavy metal. This equipment was used to analyze for Iron and Copper.

3.5.3 Biological properties

A living organism has a material structure to provide an environment for complicated chemistry of living. Chemical and physical reactions provide energy to maintain living functions and to renew structural material. Thus, consideration of biological properties is a natural extension of physical and chemical properties.

3.5.3.1. Total Coliform count (Most Probable Number Method)

Coliform bacteria are a commonly used bacterial indicator of sanitary quality of foods and water. They are defined as rod-shaped Gram-negative non-spore forming bacteria. The method that was used to determine the