CERTIFICATION OF APPROVAL

Rainwater Treatment for Domestic Use

By

Mohamad Farid bin Ismail

A project dissertation submitted to the

Civil Engineering Programme

Universiti Teknologi Petronas

In partial fulfilment of the requirement for the

BACHELOR OF ENGINEERING (Hons)

(CIVIL ENGINEERING)

SEPTEMBER 2012

Universiti Teknologi PETRONAS

Bandar Seri Iskandar

31750 Tronoh

Perak Darul Ridzuan

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Abstract

The insufficiency of clean water for today usage has been very critical case. This is due to increasing of population, modern urbanization and also pollution that can cause water source affected by contaminants. So, in order to overcome this problem, the interest is much in the filtering of roof-collected rainwater. One of the techniques was to treat the rainwater by UV irradiation and carbon adsorption. This study was carried out to investigate the effectiveness of bacteria and another contamination removal from rainwater through ultraviolet irradiation and carbon adsorption. The parameter tested for rainwater was E-coli, coliform, turbidity and color. The rainwater was taken from tile roof at the student hostel, UTP. The experiment was conducted for 2, 4, 6, 8, 12 and 24 hours continuous circulation passing through with UV lamp. The results for rainwater before undergo treatment was 1 MPN for E-coli, coliform 7.3 MPN, turbidity 1.97 NTU, color 5NTU and pH 7.76. After 24 hours treatment, the results for the treated rainwater was 0 MPN for E-coli, 0MPN for coliform, turbidity 3.19NTU, color 7.7NTU and pH 6.5. The treated rainwater was safe for domestic usage according to National Standard for Drinking Water Quality. The acceptable value for drinking water for drinking water is 0MPN/100ml for E-coli, coliform 0MPN/100ml, turbidity 5NTU, color 15NTU and 6.5-8.5 for pH.

1.0 Introduction

1.1 Background

Nowadays, the insufficiency of clean water for today usage has been very critical case. This is due to increasing of population, modern urbanization, and also pollution that can cause water source affected by contaminants. So, in order to overcome this problem, the interest is much in the filtering of roof-collected rainwater (1, 2).

This practice has been used in many countries for thousands of years (2, 3). Although this solution is attractive from an ecological point of view, it is necessary to measure the quality of harvested rainwater due to the potential for health risks as a result of chemical and microbiological contaminants.

Although a number of studies have found collected rainwater to be non potable, showing unacceptable levels of microbiological contamination and poor physicochemical qualities, "a clear consensus on the quality and health risk associated with treatment of roof collected rainwater has not been reached" (1, 3, 5).

As for Malaysia, the awareness of treatment of harvesting the rainwater is still very low. People still have doubt on the reliability of using the treated harvest rainwater even for toilet flushing use. This happened maybe because we still lack of ample local or domestic data on its reliability and sustainability (4, 5).

1.2 Problem Statement

Previously, people will not worry so much about the quality of the rainwater but then since the rapid development of this country and improvement in education background, people begin to question about the reliability and quality of the rainwater. The treatment and harvesting method gives some question to the surrounding people on how they can confirm that the filtration of harvesting rainwater is free from any contaminants that can affect their health. So, the steps need to be taken by government and the media in order to enhance the usage of the harvesting system among local people (9, 11).

The basic problem is to determine the type of filtration that will be used to filter the rainwater before it can be regarded as safe to be utilized by the public and eventually designing the filtration system based on several parameters (pH, TSS, bacteria, etc.). This test will be very important in order to make sure the health of the public guaranteed should they adopting this system as well as become the reliable information to convince the public to embark on using the rainwater treatment system for the respective area of study (1, 5, 10).

The establishment of a lot of industrial area and the affordability of owning the vehicle have increased the number of pollutants agents that free the contaminants into the air. Another concern of the society is about the cleanliness of the rooftops before the rainfall as well as the constituents of the roofs or roofing material that may contain hazardous elements. So, a thorough study needs to be done in determining the quality of the harvested rainwater based on several criteria mentioned above according to the places or sites (6, 7).

All of the situations above can be summarized as below:

1. A traditional method that has done in the harvesting system need to be implemented by a modern filter in order to get the rainwater free from contaminants (5, 6).
2. The interaction between media and local people are important so that they can try filter to use on their rainwater harvesting system.
3. The test need to be conduct in order to get the accurate data and this is to make sure that the rainwater is safe to be use as domestic usage.

1.3 Objective & Scope of Study

1.3.1 Objectives

There are three main objectives that need to be achieved by the end of this project which are:

1. To study and compare on data taken from rainwater filtration which is consist of influent and effluent based on their functionality, and the compatibility with the domestic use in Malaysia.
2. To develop a suitable rainwater filter prototype based on the result of the research that has been carried out.
3. To test the prototype on selected area whether the functionality meet the requirement based on the research findings that has been carried out.

1.3.2 Scope of Studies

There are three main elements in this scope of studies which are:

1. Rainwater
2. Filter
3. Test on the data

Rainwater is natural source that is very important to plant and human being and the continuing of life are depending on it. Without water life on earth will not exist.

This research will be focusing on the implementation of filter in water catchment system that has been customized based on the other country and certain part in Malaysia nowadays.

Apart from that, this research also will be focusing on the data test that will be conduct so that it is functioning as expected and can fully support all of the system functions. In Malaysia, the standards of the water are observed using the Water Quality Index (WQI) and the effluent discharge standards of the Environmental Quality Act (EQA) (3, 6, 9, 10).

1.4 Relevancy to the Project

This project is very relevant as currently we still do not have the data of the rainwater quality for the area of study chosen. This project will enable those who want to embark on the rainwater treatment system at their residence suffice information on the quality level of rainwater so that their confidence level to use this system for their daily usage is 100%.

1.5 Feasibility of the Project Within Scope and Time Frame

The following are the goals to be achieved for the project during the first four months (FYP 1) period;

- Review of literature related to the topic.
- Determine the parameters that going to be tested.

In the remaining four months of the project (FYP 2), the collection of sample will be done and the tests will be executed at the Environmental Engineering Laboratory.

Basically, the project is feasible within the scope and time frame if proper planning is done. Up until now, everything is on track and all of the equipments and materials needed for the project are available in the Environmental Engineering Laboratory.

2.0 Literature Review

The initiative of Malaysian Government to enhance the rainwater treatment by implementing the usage of filter in water catchment system through one of its ministry which is Ministry of Energy, Green Technology and Water has been started since 1997 where "Towards Greener Environment" program had been launched. The Ministry of Ministry of Energy, Green Technology and Water actually implement the usage of filter through all of these initiatives. Filtration is needed to make sure the rainwater tested is clear from bacteria and other things that can affect our health. So, in order to get clearer on this experiment, let's have a little look at this basic explanation (16, 18, 20).

2.1 Definition of Water

Rainwater harvesting has been practiced for over 4,000 years throughout the world, traditionally in arid and semi-arid areas, and has provided drinking water, domestic water and water for livestock and small irrigation. So, in our modernisation today, we can filter the harvested rainwater so that we can use it for our daily usage.

Throughout history, human will settle close to water sources, along rivers, besides lakes and near natural springs (5,6). Safe drinking water is important in the control of many diseases such as diarrhea, cholera, typhoid, infections hepatitis and bacillary dysentery.

The colorless, odorless, tasteless and calorie free fluid called water is vital to all life living on the earth. It is essential to man, animals and plants. Without water life on earth will not exist (9,10).

Water shortages are relevant not only to water scarce regions but also to those with an appropriate water supply infrastructure in place, due to the need to secure a stable water supply that allows for rising water demand, rapid urbanization and climate change. Rainwater harvesting and treatment constitutes one of the most feasible solutions to coping with present conditions, and several countries are reappraising its value (12,13).

The importance of water as a vehicle for spreading diseases has long been recognized and there are numerous reports concerning human health in relation to water supply and sanitation. It is estimated that 80% of all human diseases in the world is associated with unsafe potable water (17,18).

2.2 Situations in Malaysia

In general, Peninsular Malaysia is formed of highland, floodplain and coastal zones. The Titiwangsa Range forms the backbone of the peninsula, which runs from the Malaysia–Thailand border in the north to the south over a distance of 483 km and separates the eastern part from the western (24,25).

The climate of the peninsula is very much influenced by two main monsoons: the southwest monsoon (SWM) from May to August and the northeast monsoon (NEM) from November to February (27,28). The coast that is exposed to the NEM tends to be wetter than those exposed to the SWM.

The high range of the Titiwangsa prevents the NEM winds from reaching the western areas of the peninsula, which has caused these areas to become drier than the eastern part. Thus, due to them, in Malaysia we are blessed with an ample supply of water because of abundant rains.

Normally we received rainfall averaging around 2400mm annually for Peninsular Malaysia, 2360mm for Sabah and 3830mm for Sarawak. However, increasing demand by our industry, agricultural and household users had made our existing water supply infrastructure strained (28,30).

In addition of that, the tariff of water price in Malaysia is also keep on increasing.

Table 2.1 below is the table of the water tariff according to each state for 2009 and 2011.

2009		2011	
STATE	**AVERAGE WATER TAARIF (RM/m3)**	**STATE**	**AVERAGE WATER TAARIF**
PULAU PINANG	O.31	PULAU PINANG	O.31
TERENGGANU	0.52	TERENGGANU	0.52
KEDAH	0.53	KEDAH	0.67
KELANTAN	0.55	KELANTAN	0.55
SARAWAK	0.56	SARAWAK	0.56
PERLIS	0.57	PERLIS	0.57
PAHANG	0.57	PAHANG	0.57
BINTULU	0.61	BINTULU	0.61
SARAWAK (2) (BINTULU)	0.62	NEGRI SEMBILAN	O.68
NEGRI SEMBILAN	O.68	MELAKA	0.75
MELAKA	0.72	PERAK	0.73
PERAK	0.73	SELANGOR	0.77
SELANGOR	0.77	LABUAN	0.90
LABUAN	0.90	SABAH	0.90
SABAH	0.90	JOHOR	1.05
JOHOR	0.98		
AVERAGE	**0.65**	**AVERAGE**	**0.67**

Note: Average for first 35m^3

2.3 Domestic Water Consumption

Residential area receives the biggest portion on domestic water consumption. During 2006, domestic usage accounted for approximately 60% of the total water demand. Another 40% remaining consumption of water is going to agriculture, commercial and industrial consumption accounted for the Malaysia's domestic water consumption per capita per day is one of the highest in Asia (13,14).

The increasing of water consumption per capita-day from 130 l–139 l in 1997 to 148 l in 2006 in Malaysia. The main factors for domestic consumption are as follow; population growth and climate change. For a typical house, the volume of water used for drinking and cooking is much lower compare for toilet flushing, showering and bathing, and in washing machines and dishwashers (15,16).

2.4 Component of Rainwater Treatment System

There are two main functions of Rainwater Treatment System which are the rainwater treatment quality of water harvested and type of filter.

2.4.1 Rainwater Harvesting

Harvesting is important as part of rainwater treatment as it will be supporting and managing the system that will be developed. Rainwater harvesting is divide into two parts:

a) **Content Creation**

In Malaysia, as a country which receives a very high precipitation throughout the year is not fully capitalized on this (3,4,6). Rainwater harvesting basically is a technology used to collect, convey and store rain for later use from relatively clean surfaces such as a roof, land surface or rock catchment. The water is generally stored in a rainwater tank or directed to recharge groundwater. Rainwater harvesting has been defined by Pacey and Cullis (1986) as the practice of collecting and using precipitation from a small catchment area (roofs, artificial surfaces at ground level and land surfaces with slopes less than 50 - 150 m in length).

b) Category

The practice of collecting rainwater from rainfall events can be classified into two broad categories: land-based and roof-based. Land-based rainwater harvesting occurs when runoff from land surfaces is collected in furrow dikes, ponds, tanks and reservoirs. Roof-based rainwater harvesting refers to collecting rainwater runoff from roof surfaces which usually provides a much cleaner source of water that can be also used for drinking.

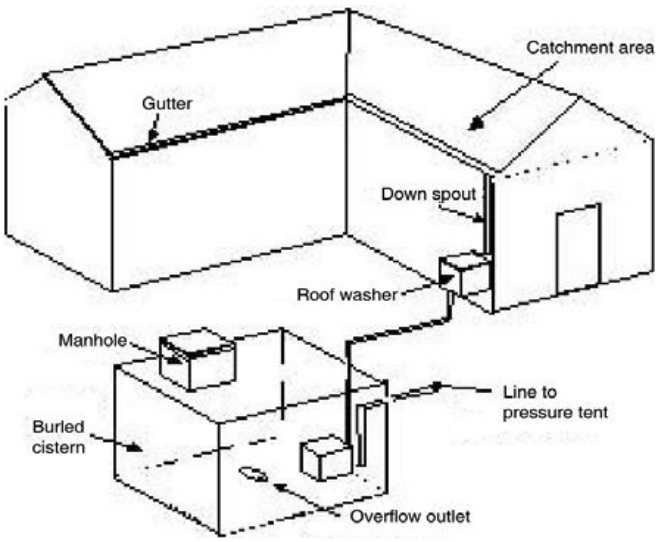


Fig 2.3.1 Rooftop Rainwater Harvesting System

As water from catchment area will be flowing through the gutter, the need to have a proper gutter system is paramount in order to increase the efficiency of collecting the rainwater. Thus a proper gutter system must be designed and installed around the rooftop to make sure that all the rainwater will go to the gutter system accordingly (5-8).

2.4.2 Quality of rainwater treatment

There is a difference between "pure water" and "safe drinking water"(5,6). Pure water, often defined as water containing no minerals or chemicals, does not exist naturally in the environment. Good quality (potable) drinking water is free from disease-causing organisms, harmful chemical substances and radioactive matter, tastes good, is aesthetically appealing and is free from objectionable colour or odour. Safe drinking water, on the other hand, may retain naturally occurring minerals and chemicals such as calcium, potassium, sodium or fluoride which are actually beneficial to human health. These will impart a taste to the water that may take some getting used to. Contrary to the popular perception that rainwater harvested from rooftops is nearly as clean as pure water, a number of contaminants can be presence in such water but actually it can be resolved by having a few measure in water quality to bring it within acceptable level using simple and inexpensive devices (9,10).

2.4.3 Type of Filter

2.4.3.1 Ultraviolet (UV) Filter

This filter use germicidal irradiation for a disinfection that use UV light to kill microorganism. DNA’s nucleic acid of the microorganism will be disrupted due to this radiation (16,18).Since mid-20th century, this application has been accepted for medical sanitation and also for sterile work facilities. Nowadays, this method has been used for drinking and wastewater sterilize.According to the research that have done, this method is highly effective to kill microorganism as this method is designed for exposed environment such as water tanks and sealed rooms. Effectiveness of this method can be seen on how long the microorganism can stand within this type of filtration by factors such as Electro Magnetic (EM) wavelength, particles that prevent microorganism exposed to UV and time taken the microorganism withstand to the UV. So, we can assume the system depends on line-of-sight exposure of UV light towards the microorganism (20,21).

2.4.3.2 Reverse Osmosis (RO) Filter

The process of osmosis is natural. Reverse osmosis is whereby solvent from high solute region to low solute region through semipermeable by excess osmotic pressure applied (11,12). The separation of seawater and brackish water to get pure water is the largest and important function of RO. The drinking water produced from the low-pressure side when seawater or brackish water is pressurized. The setup of reverse osmosis is just same as osmosis process; high concentration area is applied with pressure where there are two forces which influencing the water movement (13).

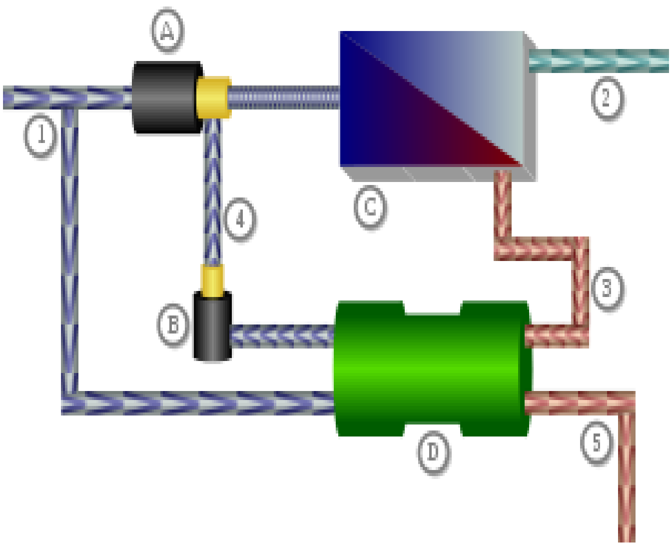


Figure 2.3.3.2 Schematics of a reverse osmosis system (desalination) using a pressure exchanger.

1: Sea water inflow,

2: Fresh water flow (40%),

3: Concentrate flow (60%),

4: Sea water flow (60%),

5: Concentrate (drain),

A: Pump flow (40%),

B: Circulation pump,

C: Osmosis unit with membrane,

D: Pressure exchanger

2.4 Advantages of Rainwater Treatment System Implementation

There are many advantages of implementing Rainwater Harvesting System such as (24,25,27) :

2.4.1 Flexibility, Accessibility and Convenience

Local people have the freedom to put the filter on what position at their home. The filter also available in any size so this make ease to use them.

2.4.2 Cost Saving

By using this rainwater harvesting system, local people can use the rainwater for their daily life such as for planting, car wash and absolutely for drinking if rainwater already confirmed free from any contaminants. They also do not need to pay for their water bill for monthly usage.

2.4.3 Green Environment

Rainwater harvesting for treatment can be one way to help our environment become green. By treating the rainwater, it can make the natural source of water has no wastage because we can use treated water for our daily usage.

2.5 Choosing the Suitable Filter for Rainwater Treatment System

There are several requirements that need to be evaluated in the process of choosing the right filter for Rainwater Harvesting System which are the technical requirement, financial requirement and functional requirement (3,4).

a) **Technical Requirement**

The platform should have low technical complexity as the users come from non technical background such as local people. Some examples of common filter are Ultraviolet (UV) and Reverse Osmosis (RO) filter.

b) **Financial Requirement**

The platform cost and also the maintenance cost must be reasonable and not to expensive as this filter can be used among all local people. Thus, choosing an open source platform is the best option based on the financial status of the household.

c) **Functional Requirement**

The platform must user-friendly and have clear interface so that it can encourage users to use it. Green environment is most targets so that there is no pollution occurs because of this filter.

3.0 Methodology

3.1 Sampling/Treatment System Design

The quality of rainwater from a tile and galvanized – iron type roof, clay tile and zinc catchments that added with amount of 0.1g bird faeces will be analyzed over a certain period of time. A portable filtration system will be designed to treat the rainwater. The ultraviolet filter will be put in the first container and activated carbon in the second container. The water in first container will be circulating according to time that have been scheduled and after the first procedure has been done, the water then will get to flow to the second container, the sample will then put in the bottle. The process will continuously until the scheduled has come to an end. The sample then will be immediately taken to the lab for further analysis and test.

Figure 3.1.1 Apparatus for treatment system

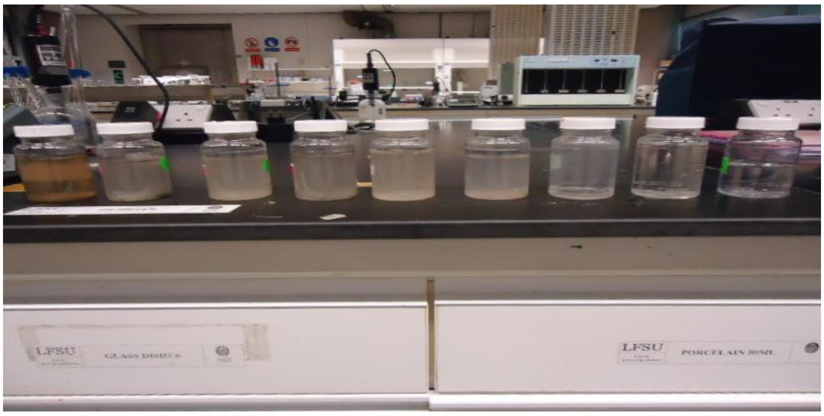


Figure 3.1.2 The sample is taken to lab for further test

3.2 Process Flow Methodology

In a nutshell, this is the process flow of methodology used for this project. In the early stage, the research will be done to understand deeper about the subject as well as determining the variable that might affect the result of the study either directly or indirectly. Below is the process flow of the methodology of the project:

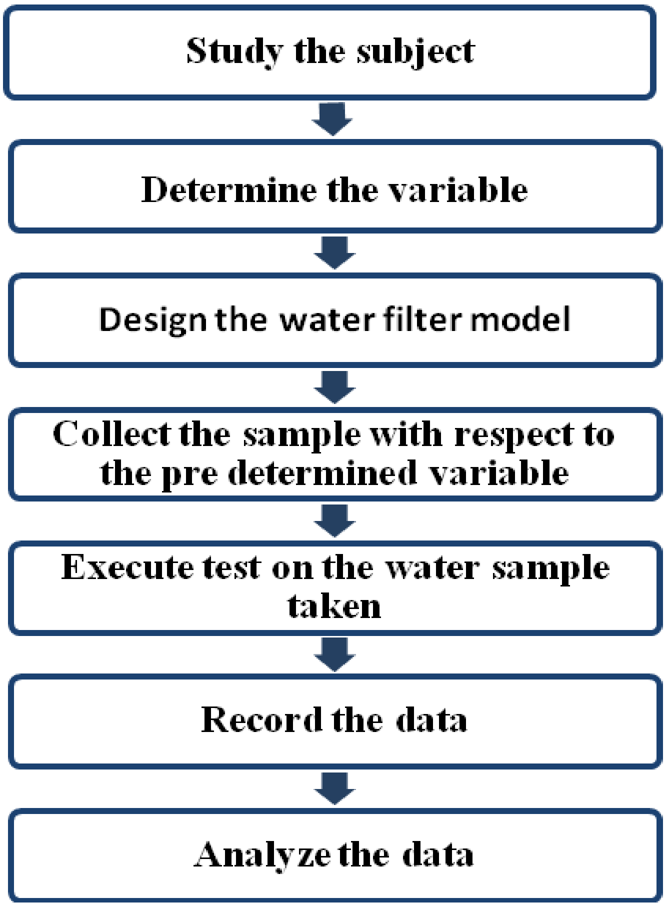


Figure 3.2

3.2.1 Tests

Usually the water quality is defined by analyzing it in terms of it's:

1. **Chemical Content**: Hardness (calcium + magnesium), Metals (iron etc), nutrients (nitrogen and phosphorus), chloride, sodium, organic compounds, etc.
2. **Physical Content**: Turbidity, colour, odour, pH, dust particulate etc.
3. **Biological Content**: Fecal coliform, total coliform, viruses, etc

For this project, we are focusing on finding out the **physical** and **biological** content of the influent and effluent of rainwater. Influent means the rainwater before treated and effluent means rainwater after go through filtration process.

3.2.1.1 pH

pH indicates the ratio of hydrogen ions (acidic) to hydroxyl ions (alkaline) on a logarithmic scale from 0 (pure acid) to 14 (pure alkaline). Pure water is 7.0, meaning that there is an equal balance of hydrogen ions and hydroxyl ions. Color comparators can be used to find pH by methods similar to those for determining chlorine residuals.

3.2.1.2 Total Suspended Solids (TSS)

Total suspended solids is a water quality measurement usually abbreviated TSS. It is listed as a conventional pollutant in the U.S. Clean Water Act. TSS is defined as solids which are suspended in the water and would be caught by a filter. Suspended solids are measured by passing sample water through a filter. The solids caught by the filter, once dried, are the suspended solids. In chemistry the non-filterable solids are the retained material called the residue.

3.2.1.3 Turbidity

Turbidity is the cloudiness or haziness of a fluid caused by individual particles (suspended solids) that are generally invisible to the naked eye, similar to smoke in air. The measurement of turbidity is a key test of water quality.

Fluids can contain suspended solid matter consisting of particles of many different sizes. While some suspended material will be large enough and heavy enough to settle rapidly to the bottom of the container if a liquid sample is left to stand (the settable solids), very small particles will settle only very slowly or not at all if the sample is regularly agitated or the particles are colloidal. These small solid particles cause the liquid to appear turbid.The units of turbidity from a calibrated nephelometer are called Nephelometric Turbidity Units (NTU)

The standard value set by WHO for turbidity is 25 NTU.

3.2.1.4 Color

Testing for color can be a quick and easy test which often reflects the amount of organic material in the water, although certain inorganic components like iron or manganese can also impart color. The color of water sample can be reported as:

- ***Apparent color*** is the color of the whole water sample, and consists of color from both dissolved and suspended components.
- ***True color*** is measured after filtering the water sample to remove all suspended material.

In water with low turbidity, the apparent color corresponds closely to the true color. However, if turbidity is high, the apparent color may be misleading. To determine the true color, first filter the water through clean white filter paper before it is compared with the standards.

Because the filter paper often removes some true color from the first portion of the sample, discard the first 100-ml which pass through the filter and use the next portion for the color comparison. Make the color determination by matching the sample color with color standards in a color comparator.

Green can represent copper leaching from copper plumbing and can also represent algae growth. Blue can represent copper also and can represent a syphoning of industrial cleaners in the tank of commodes, commonly known as backflowing. Reds can be both signs of rust from iron pipes and airborne bacteria from lakes, etc. Black water can indicate sulfur reducing bacteria growth inside of a hot water tank set at less than 120 degrees Fahrenheit.

The standard set by WHO for potable water is 15 mg Pt/L/TCU

3.2.1.5 Bacteria

Total coliform, fecal coliform, and *E. coli* are few kinds of bacteria that commonly be as indicators of drinking water quality. The total coliform group is a large collection of different kinds of bacteria. Fecal coliforms are types of total coliform that mostly exist in feces. *E. coli* is a sub-group of fecal coliform. When a water sample is sent to a lab, it is tested for total coliform. If total coliform is present, the sample will also be tested for either fecal coliform or *E. coli*, depending on the lab testing method. ***Figure 3.3*** below show clearer relationship between those bacterias.

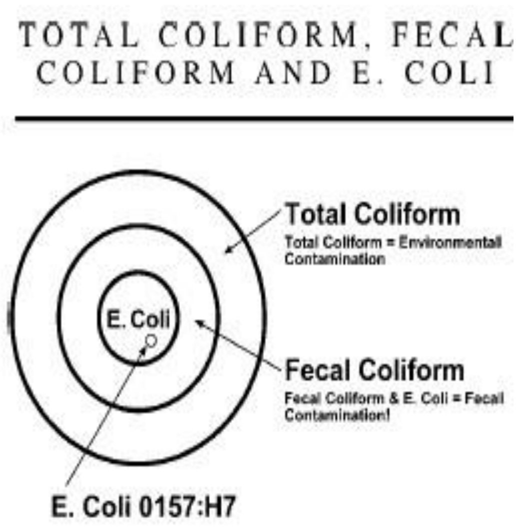


Figure 3.2.1.5

3.2.1.5.1 Total coliform bacteria

They are commonly found in the environment (e.g., soil or vegetation) and are generally harmless. If only total coliform bacteria are detected in drinking water, the source is probably environmental. Fecal contamination is not likely. However, if environmental contamination can enter the system, there may also be a way for pathogens to enter the system. Therefore, it is important to find the source and resolve the problem.

3.2.1.5.2 Fecal coliform bacteria

They are a sub-group of total coliform bacteria. They appear in great quantities in the intestines and feces of people and animals. The presence of fecal coliform in a water sample often indicates recent fecal contamination. Meaning that there is a greater risk that pathogens are present than if only total coliform bacteria is detected.

3.2.1.5.3 *E. coli*

It is a sub-group of the fecal coliform group. Most *E. coli* bacteria are harmless and are found in great quantities in the intestines of people and warm-blooded animals. Some strains, however, can cause illness. The presence of *E. coli* in a drinking water sample almost always indicates recent fecal contamination. Meaning there is a greater risk that pathogens are present. Most outbreaks have been caused by a specific strain of *E. coli* bacteria known as ***E. coli O157:H7.***

3.2.1.6 Conductivity

Conductivity is the ability of a material to conduct electric current. The principle by which instruments measure conductivity is simple - two plates are placed in the sample, a potential is applied across the plates (normally a sine wave voltage), and the current is measured. Conductivity (G), the inverse of resistivity (R) is determined from the voltage and current values according to Ohm's law: G = I/R = I (amps) / E (volts). Conductivity can be used as a measure of total dissolved solids (TDS). Conductivity in water is affected by the presence of inorganic dissolved solids such as chloride, sulfate, sodium, calcium and others.

3.2.1.7 Quality Water Standard

Parameter	Acceptable Value	Source of reference
Total Coliform	5000MPN/100ml	WHO1
Turbidity	5 NTU	WHO2
Colour	15 TCU	WHO1
Ph	6.5-8.5	MAL
Total Dissolve Solids	1500 mg/L	WHO1

WHO1: Refers to WHO International Standards for Drinking Water 1963.
WHO2: Refers to WHO Guidelines for Drinking Water Quality Vol. 1&2 1984.
MAL:Refers to values adapted for Malaysian conditions
Reference: National Standard for Drinking Water Quality, 2nd version, 2004

3.3 Test Procedure and Equipments Needed

3.3.1 Total coliform and e coli

There are two test can be done which are to determine the presence and absence of bacteria and another one is to determine the quantity of bacteria in the water sample.

Equipment: Quanti Tray

Figure 3.3.1 Quanti Tray

3.3.1.1 Presence or absence

The test that will be performing only determines the presence or absence of the bacteria. It gives no indication of the number of bacteria present. To obtain this, we need to do a colony count. The procedure is as follows:

1) Open the vial, being careful not to contaminate the broth. Pour the water sample into the vial and close the cap.
2) Incubate for 24 hours at room temperature
3) If the color changes from reddish purpl to yellow, this indicates that there are coliform bacteria present.
4) Dispose of your bottle as instructed

3.3.1.2 Quantification

We will be using IDEXX Quanti-Trays that is designed to give quantitated bacterial counts of 100 ml sample using special reagents.

1) Use one hand to hold a Quanti-Tray upright with the well side facing the palm.
2) Squeeze the upper part of the Quanti-Tray so that the Quanti-Tray bends toward the palm.
3) Open the Quanti-Tray by pulling the foil tab away from the well side. Avoid touching the inside of the foil or tray.
4) Pour the reagent/sample mixture directly into the Quanti-Tray, avoiding contact with the foil tab. Allow foam to settle
5) Place the sample-filled Quanti-Tray onto the rubber tray carrier of the Quanti-Tray Sealer with the well side (plastic) of the Quanti-Tray facing down to fit into the carrier
6) Seal according to the Quanti-Tray Sealer instructions
7) Incubate according to reagent instructions
8) Count positive wells and refer to the MPN table on the back of this instruction sheet to find the MPN.
9) Dispose of media in accordance with good laboratory practices

3.3.2 pH Test

Equipment: pH meter

Figure 3.3.2 pH Meter

1) Submerge electrode with temperature probe in the sample of wash solution (turn the meter on first). Stir for a few seconds.
2) Allow the readings to stabilize (a minute or so) and record the results

The measurement of the pH of a solution is dependant on the temperature of the solution. This is why whenever pH is measured the temperature must be included.

Most pH meters will compensate for temperature automatically. The temperature probe must be positioned as close as possible to the pH probe for accuracy reasons.

The standard reference temperature for calibration etc. is 25 C.

3.3.3 Turbidity Test

Equipment: Turbidity meter

Figure 3.3.3 Turbidity Meter

1. Prepare the turbidity meter for use according to the manufacturer's directions.
2. Use the turbidity standards provided with the meter to calibrate it. Make sure it is reading accurately in the range in which you will be working.
3. Shake the sample vigorously and wait until the bubbles have disappeared. You might want to tap the sides of the bottle gently to accelerate the process.
4. Use a lint-free cloth to wipe the outside of the tube into which the sample will be poured. Be sure not to handle the tube below the line where the light will pass when the tube is placed in the meter.
5. Pour the sample water into the tube. Wipe off any drops on the outside of the tube.
6. Set the meter for the appropriate turbidity range. Place the tube in the meter and read the turbidity measurement directly from the meter display.
7. Record the result on the field or lab sheet.
8. Repeat steps 3-7 for each sample.

3.3.4 Total Suspended Solid Test

Equipment:

- Desiccators
- Drying oven, for operation at 103 to 105°C
- Analytical balance, capable of weighing to 0.1 mg
- Magnetic stirrer with TFE stirring bar
- Wide-bore pipettes
- Graduated cylinder
- Low-form beaker
- Glass-fibre filter disks with organic binder
- Filtration apparatus, which can be any one of the following:
    - Membrane filter funnel
    - Gooch crucible, 25 mL to 40 mL capacity, with Gooch crucible adapter
    - Filtration apparatus with reservoir and coarse fritted disk (40 to 60 um) as filter support
- Filter flasks, of sufficient capacity for sample size selected
- Vacuum pump
- Tubing
- Stop watch

3.3.5 Conductivity Test

Equipment: Conductivity meter

Figure 3.7

1. Prepare the conductivity meter for use according to the manufacturer's directions.
2. Use a conductivity standard solution (usually potassium chloride or sodium chloride) to calibrate the meter for the range that you will be measuring. The manufacturer's directions should describe the preparation procedures for the standard solution n.
3. Rinse the probe with distilled or deionized water.
4. Select the appropriate range beginning with the highest range and working down. Read the conductivity of the water sample. If the reading is in the lower 10 percent of the range, switch to the next lower range. If the conductivity of the sample exceeds the range of the instrument, you may dilute the sample. Be sure to perform the dilution according to the manufacturer's directions because the dilution might not have a simple linear relationship to the conductivity.
5. Rinse the probe with distilled or deionized water and repeat step 4 until finished.

3.4 Project Activities

In the beginning of the project, everything is focused on the theoretical reading and understanding the project scope. In this stage, critical analysis of the existing features of Rainwater Harvesting for Treatment System need to be done in order to find the features that has not being develop yet and also meet the user's requirement based on the test done.

Through the whole development of project, the analysis that have been done will be use to develop the framework of the system, determine the best way to reside the harvest system and obviously finding the suitable filter to use for the interface and the features. The next step is developing the system. To begin, there are always many tutorials on the internet as guidance in order to understand how the whole process works provided on the net and forum. Then, continue developing the system, part by part and testing the features so that its meet the requirement and also running as it supposed to be. The whole process need to be repeated while developing more other part until finally, finishing the whole system.

After complete the whole development and testing, the system needs to be tested by users themselves in the session.

3.5 Key Milestone

Below are the key milestone that need to be achieve throughout both of the semester of final year project 1 (FYP I) final year project 2 (FYP II).

Semester 1

Milestone	Week
Project Proposal	Week 3
Extended proposal (10%)	Week 6
Proposal Defense (40%)	Week 9
Interim Report (50%)	Week 11

Table 1: Key milestone for FYP I

Semester 2

Milestone	Week
Progress Report (10%)	Week 7
Pre-SEDEX (10%)	Week 10
Dissertation (40%)	Week 12
VIVA (30%)	Week 13
Technical Report (10%)	Week 14

Table 2: Key milestone for FYP II

3.6 Gantt chart

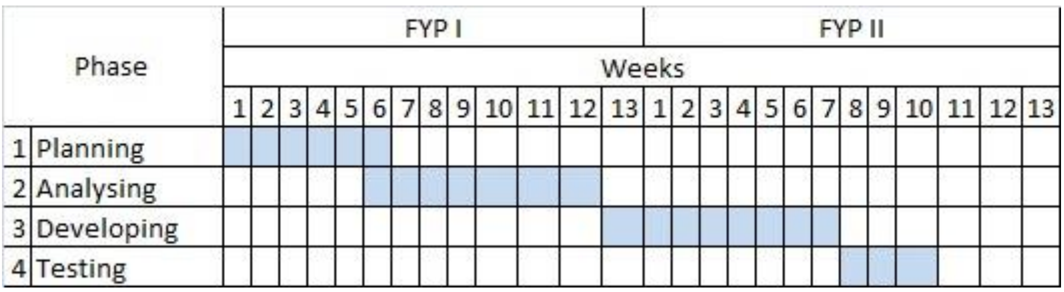


Table 3: Gantt chart

3.7 Tools

The tools that needed of this project:

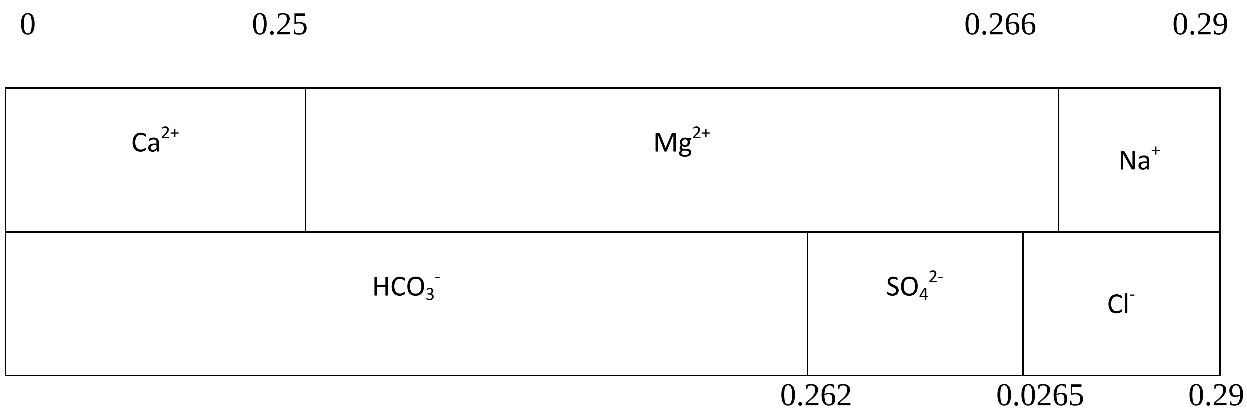
i. Rainwater Harvest System
ii. Rainwater Filter
iii. Apparatus in the Environment Lab for data testing

4.0 RESULT AND DISCUSSION

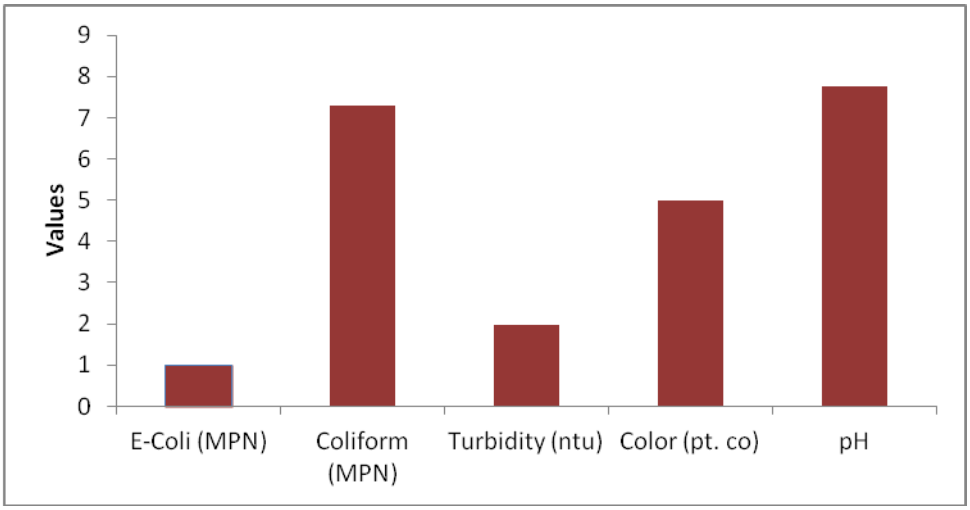
Hardness - **13.2186 as CaCo3 mg/L**

Minerals	Conc.	Equiv./L	Meq/L
Ca	5.000	20.00	0.250
Mg	0.200	12.15	0.016
Na	0.559	23.00	0.024
K	0.462	39.00	0.012
Total			0.303
HCO3	16.000	61.00	0.262
SO4	0.147	48.00	0.003
Cl	0.876	35.50	0.025
Total			0.290

Percent Error %	4.336659



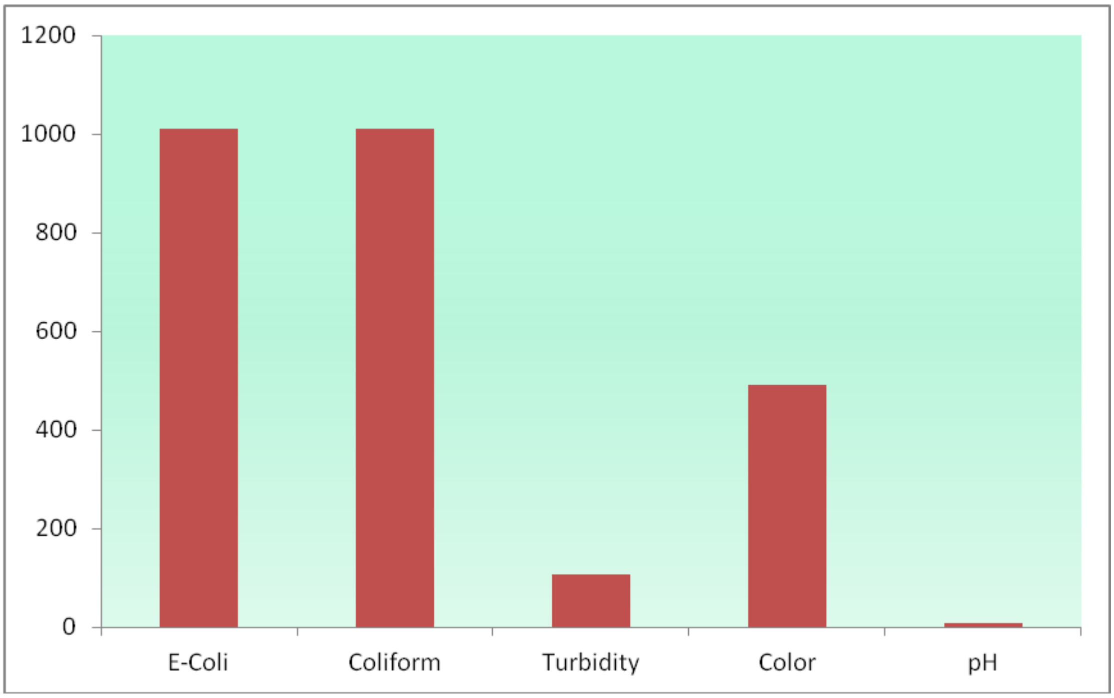
Rainwater Characteristic (Influent)



The graph shown the characteristics of rainwater parameter without added any bird's faeces.

Rainwater Characteristic (Influent-After added with 1g bird faeces)

- 0 day and First day (still not undergo treatment)

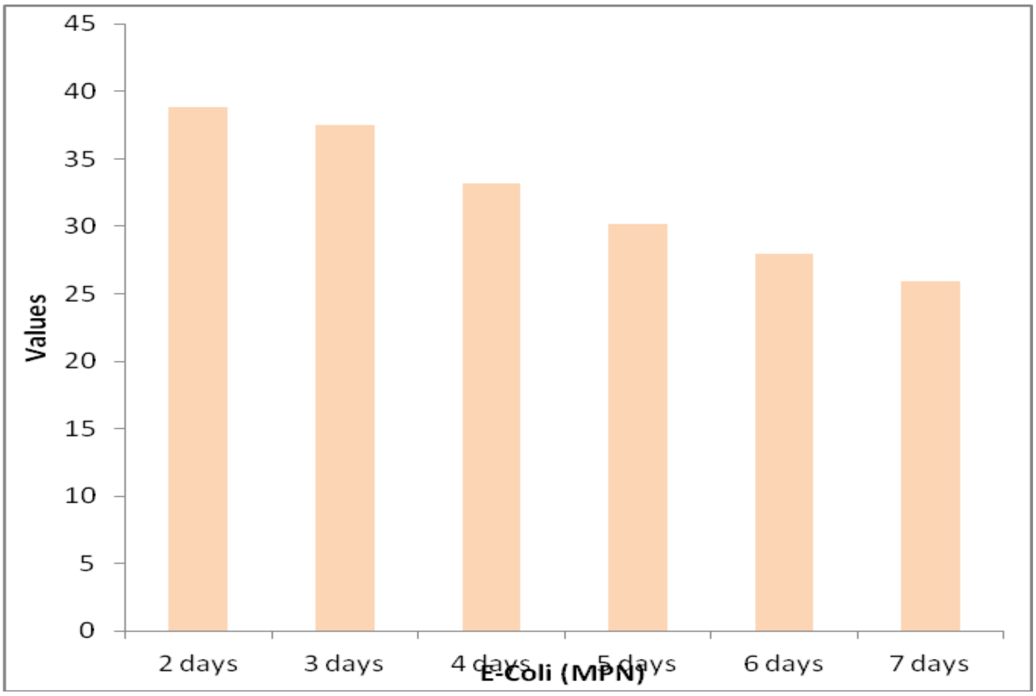


The graph showed the characteristics of rainwater after added with some amount of bird's faeces.

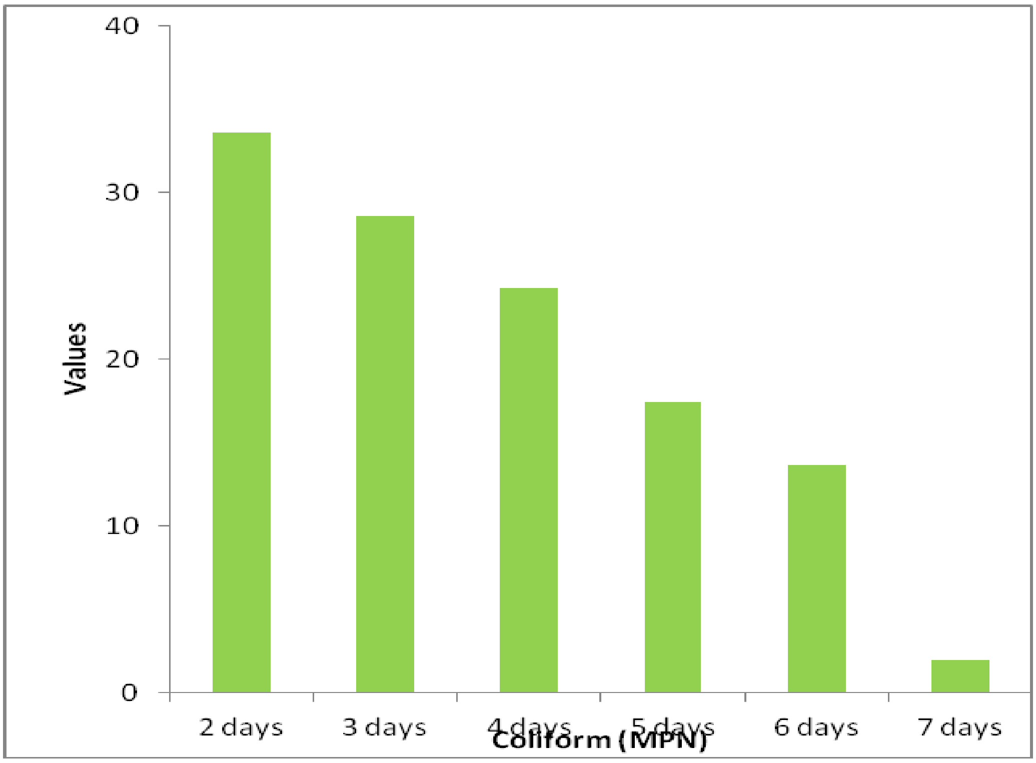
Rainwater Characteristic (Effluent- After added up with 30g bird faeces)

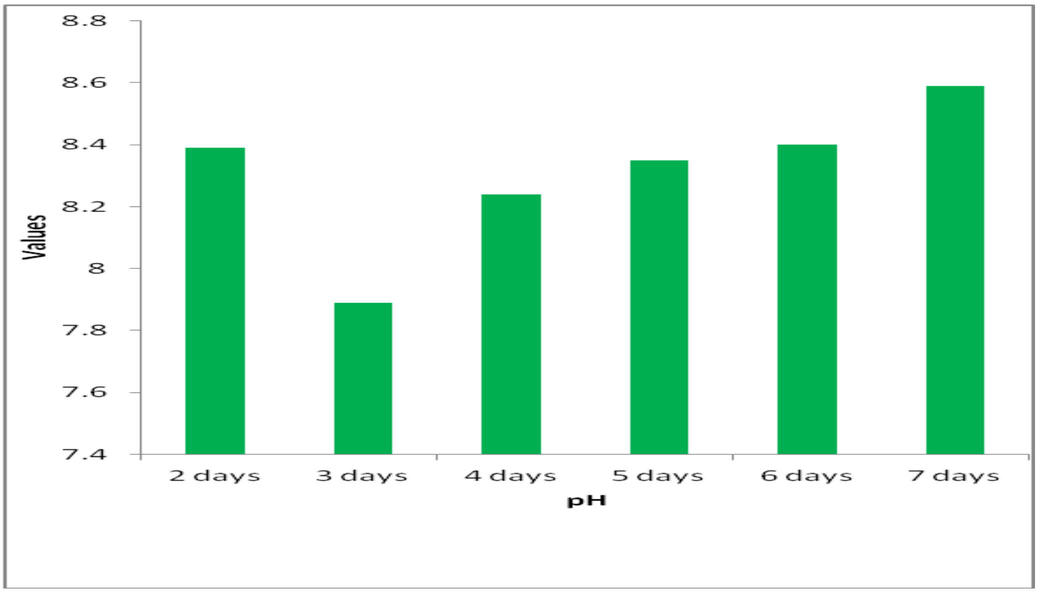
- After undergo Ultraviolet and activated carbon filter

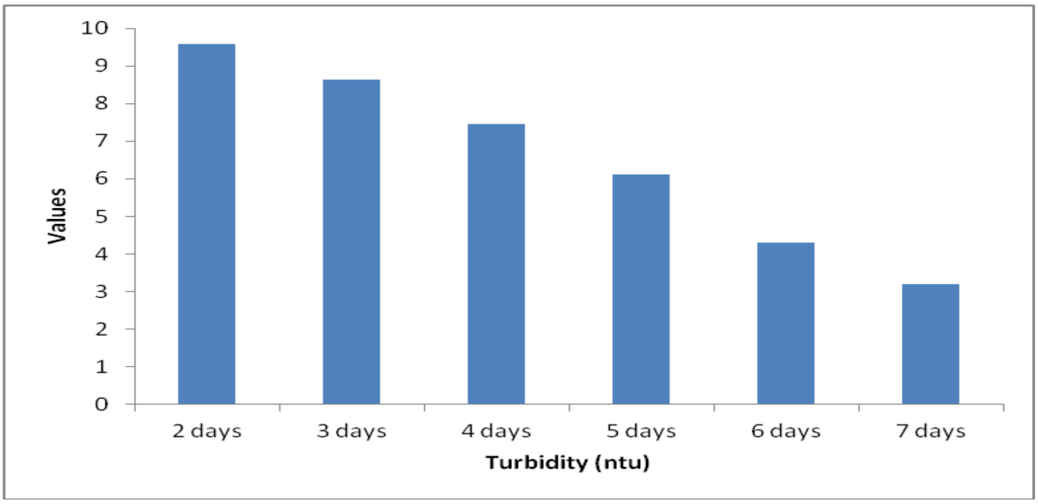
E-coli

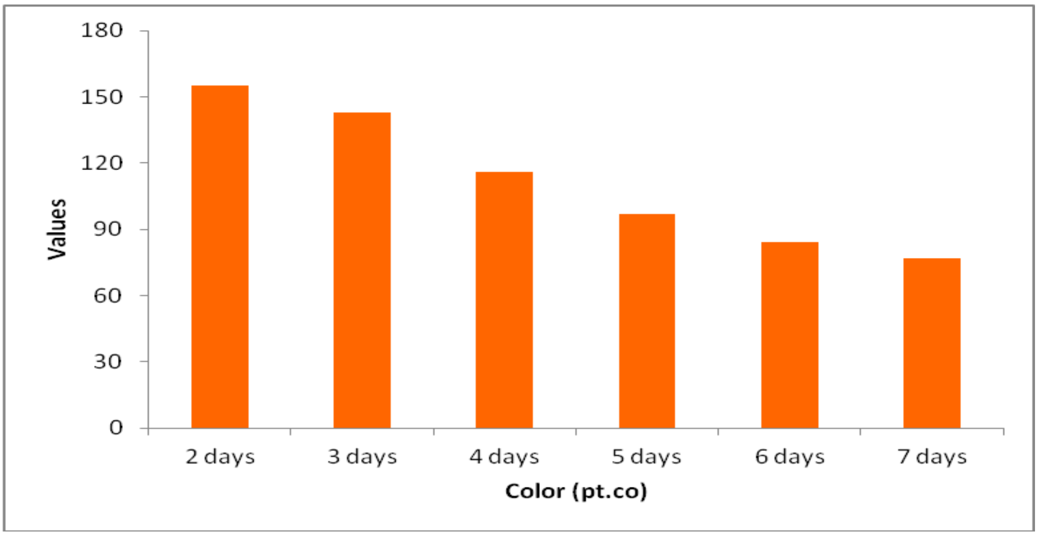


Total Coliform




8.8
8.6
8.4
8.2
8
7.8
7.6
7.4
Values
2 days
3 days
4 days
5 days
6 days
7 days
pH


10
9
8
7
6
5
4
3
2
1
0
Values
2 days
3 days
4 days
5 days
6 days
7 days
Turbidity (ntu)


180
150
120
90
60
30
0
Values
2 days
3 days
4 days
5 days
6 days
7 days
Color (pt.co)

5.0 RECOMMENDATION AND CONCLUSION

The aim of the project is to study the rainwater treatment using the filtration system and conduct the test in order to get the result that will convince common people in using rainwater as their domestic use. The study covers four important parameters which are rainwater influent, rainwater effluent, type of filter that will be use for rainwater filtration and the last one is the test that will be conducted to determine result of rainwater such as pH, conductivity, TSS etc. Based on the preliminary study done, the following can be concluded:

- The project's feasibility lies in its simplicity in implementation and the equipments are readily available; hence developing this project would be practical and feasible within the scope and time frame. Objectives can be achieved.
- The author has begun to understand and internalize some of the theory and concepts of related to this project for instance the application of rainwater filtration in environment sustainability.
- The author has conducted an initial literature review on rainwater characteristics, filtration system and managed to familiarize herself with the experimental procedures and methods.

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