THERMAL APPLICATION USING HEMISPHERICAL SOLAR STILL TO ENHANCE THE PRODUCING OF CLEAN WATER

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

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DEDICATION

A particular thank you to Allah, the Almighty God, for helping me finish my job on time and for providing me the fortitude to go through whatever difficulties I had. I would also want to thank my parents, Norhisham bin Mohd Noor and Rosesuzila Binti Maarop, for their spiritual and physical support in helping me accomplish the project. Then, I want to thank my boss, Dr. Azdiana Binti Md Yusop, for her constant advice and contributions to the achievement of this project. Furthermore, I would like thank my friend and relatives that help me during the process of making this project, without them I would not be able to complete this project alone.

ABSTRACT

Solar stills use the sun's energy to distinguish between dirty and clean water. By utilising the thermoelectric effect, which can convert different temperatures directly into electric voltage or vice versa using a thermoelectric module, is one of the components to build this solar still. Conventional solar stills have drawbacks because there are too many distinct varieties, too many of them lack monitoring systems, and they rely on the sun's heat and the air's humidity to collect clean water. By including a thermoelectric system, evaluating the water's temperature and cleanliness, and developing a real-time monitoring system, this project hopes to increase the solar still's effectiveness. The solar still's top cover may be archived by using hemispherical top cover. The solar still will be placed along with the microprocessor Arduino Uno, PH sensor, and Water level sensor in order to monitor the quantity and quality of the distilled water. The heating plate will be used to control the temperature within the hemispherical solar stills to make the evaporation process more effective. Based on this thesis, it can be concluded that Hemispherical Solar Still + River Rock + Peltier has the best efficiency which is among the other test conducted in order to find the best possible modification for the solar to enhance the solar still performance which manage to collect 108 ml of safe pH level water which is at 7.25 ph value.

ABSTRAK

Solar still menggunakan tenaga matahari untuk membezakan antara air kotor dan air bersih. Dengan menggunakan kesan termoelektrik, yang boleh menukar suhu yang berbeza secara langsung kepada voltan elektrik atau sebaliknya menggunakan modul termoelektrik, merupakan salah satu komponen untuk membina solar still ini. Solar still konvensional mempunyai kelemahan kerana terdapat terlalu banyak variasi yang berbeza, ramai daripadanya tidak mempunyai sistem pemantauan, dan mereka bergantung kepada panas matahari dan kelembapan udara untuk mengumpul air bersih. Dengan memasukkan sistem termoelektrik, menilai suhu dan kebersihan air, dan membangunkan sistem pemantauan masa nyata, projek ini berharap untuk meningkatkan keberkesanan solar still. Penutup atas solar still boleh diarkibkan dengan menggunakan penutup atas hemisfera. Solar still akan ditempatkan bersama-sama dengan mikropemproses Arduino Uno, sensor PH, dan sensor aras air untuk memantau kuantiti dan kualiti air suling. Plat pemanasan akan digunakan untuk mengawal suhu dalam solar still hemisfera untuk menjadikan proses penyejatan lebih efektif. Berdasarkan tesis ini, dapat disimpulkan bahawa Hemispherical Solar Still + River Rock + Peltier mempunyai kecekapan terbaik di antara ujian lain yang dijalankan untuk mencari modifikasi terbaik yang mungkin untuk solar untuk meningkatkan prestasi solar still ini yang berjaya mengumpul 108 ml air bersih dengan tahap pH yang selamat, iaitu pada nilai pH 7.25.

ACKNOWLEDGEMENTS

Praise be to the Almighty God, Allah, for His bounty and prayers, as well as those of His prophet, Muhammad S.A.W. , his lineage, and honourable companion. I'd want to start by expressing my gratitude to my family for always encouraging me in anything I do. They are always there to support me, even if they are unable to comprehend how engineering functions. I also want to express my gratitude to my project manager, Dr. Azdiana Binti Md Yusop, who accepted me as a student and was willing to assist and mentor me during the project's two semesters. Dealing with Dr. Azdiana was a delight. Her eagerness to assist me meant that I was able to correct and learn from my mistakes. Furthermore, unless all necessary tools and materials are borrowed, the job cannot be finished.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS AND ABBREVIATIONS

HSS	:	Hemispherical Solar Still
HSSRR	:	Hemispherical Solar Still + River Rock
HSSP	:	Hemispherical Solar Still + Peltier
HSSRRP	:	Hemispherical Solar Still + River Rock + Peltier
DC	:	Direct Current
Cm	:	Centimeter
DHT	:	Digital Humidity Temperature
GPIO	:	General-Purpose input/Output
LCD	:	Liquid Crystal Display
LED	:	Light Emitting Diode
pH	:	Value of Acidity and Alkalinity
WHO	:	World Heath Organization
VCC	:	Volatage Common Collector

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

This chapter foresees every step of the project, starting with the issue to be resolved and the goal to be accomplished. The problem statement will describe how the project approaches the problem in order to achieve its primary goal. What must be accomplished for the project to be completed is the primary goal. The project's scope of work will outline how it will be carried out and the expected results, which are outlined in the objective. The project methodology will outline the methods utilised to accomplish the project and demonstrate how the project's process flows operate.

1.1 Project Overview

The essential of clean water has become the most important factor in human's life. Thus, many approach has been taken by the authorities to increase the quality of the water to enable them to be consume by the people. One of the way is by using solar still. By utilizing hemispherical solar still method that arguably one of the most efficient method for a solar still, this project has been conducted to utilize the method and with addition of some modification for the improvement of the hemispherical solar still. This project also supported by solar panel to save and recharge to independent battery for the project. Sunlight, or solar energy, has been essential to human endeavours including farming, fishing, animal husbandry, and cartography since the dawn of civilization. In the present, solar energy is utilised to create solar-powered ships, automobiles, and planes, as well as to power homes and businesses using solar panels. The road is illuminated at night by a solar panel that has been charged all day. Solar stills, which turn contaminated water into pure water, are one example of how solar energy has been used in technology to reduce carbon footprints. By using some of the thermoelectric application, the system can be analysed and improved in terms of performances of the solar still.

1.2 Project Objective

The main focus of this project is to be able to complete the objective, identify the limitation of the project and lastly present the prototype of this project title by achieving those objectives :

a) To design a hemispherical dome solar still incoperated with the thermoelectric system that able to produce a clean water from the tap water

b) To verify the hemispherical dome solar still performance in terms of water level and pH level of the evaporated water with the temperature and humidity in solar still.

c) To compare the performance of the ordinary hemispherical solar still (HSS) with HSSRR(River Rock), HSSP(Peltier) and HSSRRP(River Rock + Peltier).

1.3 Problem Statement

In addition to raising concerns about possible waterborne illnesses, the ongoing problem of unreliable cleanliness in tap water throughout Malaysia's various regions highlights the critical need for comprehensive measures to improve water quality monitoring, treatment procedures, and public awareness campaigns in order to guarantee a consistently safe and dependable supply of drinking water for the population's well-being.

Next, because there are too many different types of conventional solar stills, many of them lack monitoring systems, and they rely on the sun's heat and the air's humidity to gather clean water so they have some limitations. This project aims to include the thermoelectric module to create the active element in order to enhance to evaporation process thus can producing more clean water.

Traditional methods of water purification, such as chemical treatments or filtration systems, are often expensive, require complex maintenance, and may not be feasible for rural communities due to their economy and the price of the tools..One promising solution is the implementation of hemispherical solar stills. Hemispherical solar stills utilize solar energy to purify water by harnessing the natural process of evaporation and condensation. These devices have the potential to effectively desalinate or purify contaminated water sources, making them an ideal technology for rural areas with access to ample sunlight.

The conventional hemispherical solar still out there still not using any independent power source. Because of that, the real time monitoring system or thermoelectric concept is not widely used to improve the performance of the solar still evaporation rate to produce more volume of clean water. This thesis aims to investigate and develop an improved hemispherical solar still design that significantly reduces the cost of obtaining clean water in rural areas by implementing the independent power source to the system.

1.4 Scope of Work

The first step in the project involved choosing materials for constructing the solar still. Subsequently, the type of Peltier or thermoelectric module to be integrated into the solar still as the active thermal medium was decided. The project then moved on to selecting the microcontroller that would function as the project's brain, controlling and monitoring all heating and sensor equipment respectively. These equipment facilitated user access to the quantity and quality of water generated after completing distillation and filtration procedures. Tap water was utilized in the project, and solar energy was harnessed to charge the battery employed in the heating process, which in turn supported the project's energy needs. The heating process was aided by a 12V battery, with a 20-watt panel generating about 2 Amps of power at 12 V. The panel required six hours of sunshine to fully charge the 12-volt battery. To facilitate the heating process, a component capable of releasing heat, specifically a Peltier, was utilized. Water vapors resulting from the evaporation process passed through the acrylic panel into a container, collecting all water vapors before undergoing filtration. Humidity sensors, identifying variations in electrical currents or air temperature, played a crucial role. The humidity level in the air needed to be equal to or greater than 65, indicating ample moisture. Following the evaporation process, a PH sensor was employed to test the PH value. The primary processing units in this project were Arduino Uno boards, responsible for controlling the monitoring system.

1.5 Project Methodology

This project is divided into two parts which are the solar still with a heating module and a monitoring system. After being heated by the heating plate, the unfiltered water was gathered in a single container. Condensation occurred simultaneously, turning the evaporation process' leftover vapor which had been contained in the solar still into pure water. The heating plate, which worked similarly to a water heater, sped up the process of turning water from a liquid into a gas. Analyzing every piece of monitored data was necessary to determine how effective the thermoelectric cooling and heating system was. The goal of this project was to use solar energy along with thermoelectric heat to warm the water and increase the amount of water that evaporates each day. An Arduino Uno R3 connected the temperature and water level sensors, while an LCD showed the results. The thermoelectric heating plate was powered by a 12V DC battery.monitoring system.

Project Flowchart

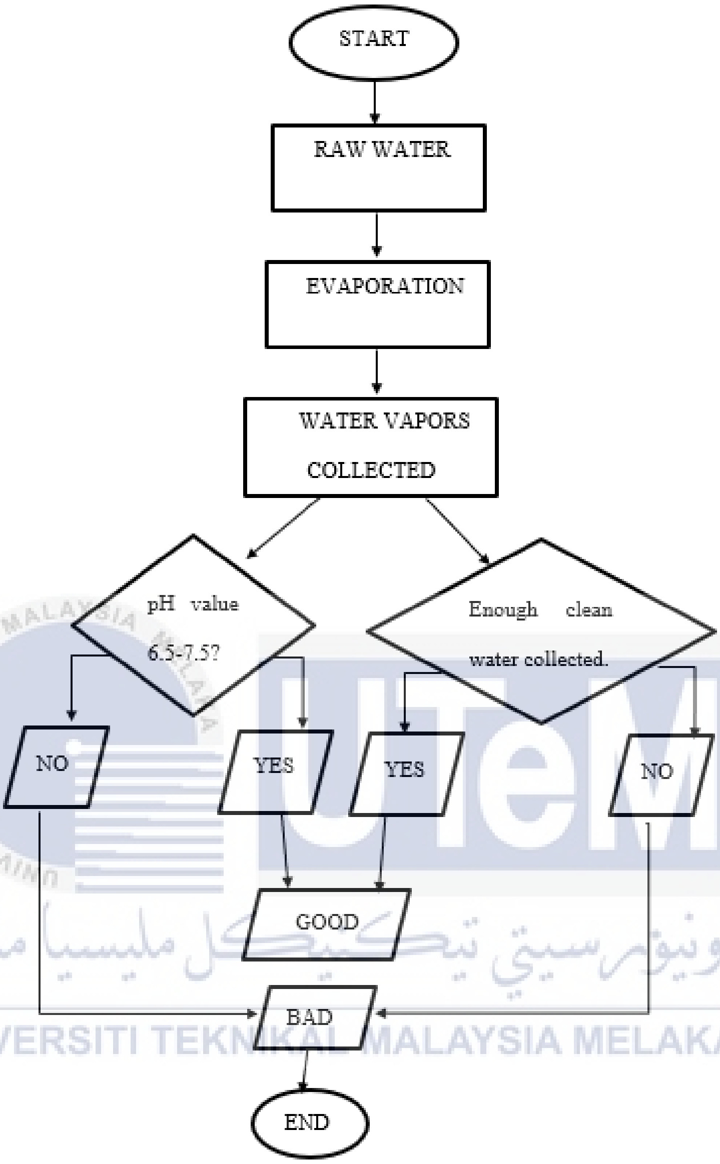

Figure 1.1 : Methodology flowchart

From the figure 1, it shows the flow of the methodolgy of this project. First and foremost, the raw uncleaned water inserted into the hemispherical solar still. Next, after the evaporation process occurred in the daylight the water vapors will be collected into the water collection tank. After that, the pH value was measured by using pH sensor and if the pH value of the collected water is around 6.5- 7.5, then the water is safe to consume according to the safe water pH level indicated by WHO [12] and if the water level is around the targeted level which is around 100 ml then the test is successful. Meanwhile, if the result is opposite of the targeted level then the test is considered unsuccessful.

1.6 Thesis Outline

In the next following chapter, the report will be organized as follows:

i. Chapter 1

Provide a brief explanation of the project's goals, challenges, history, and scope of work.

ii. Chapter 2

The background investigation is an essential part of the undertaking. It includes a background analysis of relevant prior works or periodicals that can help the endeavor.

iii. Chapter 3

The methodology will provide a more detailed explanation of the rationale for the selection of the part for the project, as well as the process and flowchart that will be employed to finish it. It will also address the flowchart, diagram, material, and component used for the project.

iv. Chapter 4

The outcome and conversation in which each project finding, mistake, and analysis will be noted and incorporated into the chapter to learn more about the project's shortcomings, strengths, and limitations. All of the project's findings will be presented graphically.

v. Chapter 5

The choice or project's final finding, its merits and shortcomings, whether it accomplishes the project's goal, recommendations for the project, and the project's future work are all included in the conclusion and future sections.

CHAPTER 2

BACKGROUND STUDY

The two components of the project the solar still and the theory of thermoelectricity and how it works are the subject of data collection and theoretical discussion in this chapter. The theory of the component is crucial since the success of the project depends heavily on how effectively the project function. The label should be positioned above the actual table and is formatted as follows:

The overview of the whole chapter is

I. Climate Scenario in Malaysia
II. Effect of Distillation and Evaporation
III. Hemispherical Solar Stills
IV. Tap Water Quality In Malaysia

2.1 Background Study

Solar water distillation is the technique of removing salts or other impurities from freshwater using the energy of the sun. Untreated water slowly warms up to high temperatures as a result of absorbing heat. The impurities are left behind as the water evaporates, cools, and condenses into vapour as a result of the heat. Low capacity and independent water supplying systems is one of the benefit of solar stills.

Previous research shows some of the review of the types of solar stills which is the paper's goal is to present a thorough overview of the many solar still types, which has passive and active design elements, single and multi-function designs[1]. There is also some research paper that examines and documents the design and operational features that affect the performance of the hemispherical solar still (HSS). Hemispherical solar stills perform better thermally than other styles of solar stills. In one study, there is a comparison between hemispherical solar still design and pyramid solar still design and hemispherical solar still design produced 3.3 l/m^2 in a day with daily efficiency of 32.02 % whereas pyramid solar still design produced about 2.73 l/m^2 with only 26.59 % [18] . This shows that hemispherical solar still design has more efficiency compare to the pyramid design. Next, in the solar still water desalination systems, thermoelectric materials have many uses. It can be used as a heater to speed up the evaporation process by raising the temperature of the water in the basin or as a cooler to boost the performance of the solar still.

2.2 Climate Scenario In Malaysia

Malaysia is a country on the equator with a hot, humid atmosphere all year round, making it an ideal location to harness solar energy. As a result, any project using sunshine may flourish in Malaysia. In Malaysia, the average temperature is between

29 and 30 degrees Celsius from mid-October to January, and between March and August, it is between 32 and 33 degrees, with certain locations occasionally reaching as high as 37 degrees. Since Malaysia, particularly the Peninsular region, gets monsoons twice a year, rainfall is abundant throughout the year. The east coast region, including Kelantan, Terengganu, Pahang, and the east region of Johor, are heavily influenced by the northeast monsoon, which occurs between October and January. The second monsoon, the southwest monsoon, occurs between June and September and affects the west coast region on Peninsula Malaysia. The weather in Malaysia is significantly influenced by the monsoon season since it may get quite cold around Kota Bharu, Kelantan, and Kuala Terengganu, Terengganu, during the northeast monsoon. Langkawi's temperature during the southwest monsoon is around 31° to 32° Celsius, hence it has little impact on the west coast region [2].

Although Klang Valley experiences abundant rainfall, it occasionally experiences the least rainfall on the Peninsula due to the region's dense urbanisation. When it rains the least, between June and September, the average rainfall may be as low as 125 millimetres, and between January and February, the average rainfall is at its lowest, at 170 millimetres. This results in the Klang Valley area receiving more sunshine, but it may be unpleasant because the temperature at that time can reach 33° Celsius, and the urban expansion taking place there makes it less comfortable for residents. Klang Valley residents typically receive 6.1 hours of total annual sunshine, which is wonderful for those who utilise solar energy; most homes, particularly those in metropolitan regions, already have solar panels installed as alternatives to run the home all day. However, as we all know, due to the fact that living expenses may often double or even treble in various regions, metropolitan areas in the current period also house the majority of the poor. As a result, those who live in poverty lack access to clean water, as well as to food and shelter. As in Klang Valley, the region also has a water shortage since the dam there occasionally experiences chemical contamination, which prevents residents from having access to water for days or even weeks at a time, which can have an impact on people's everyday lives. As a result, most residences include a water storage tank that may be used, and some houses also collect rainwater. Purifying the collected rainwater and the water in the reservoir water tank may be a great idea to utilise the water for everyday living as rainwater can occasionally be less clean than the water given by the local operator since rainfall can include some undesired material [3]. The average annual temperature of Durian Tunggal, Melaka is depicted in Figure 2.1 as falling between 29°C and 31°C.

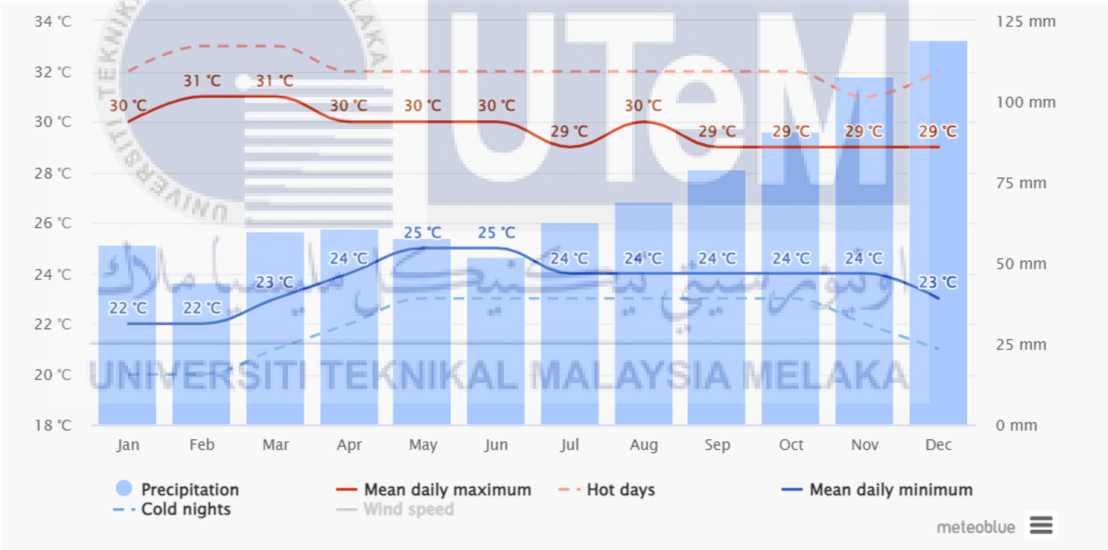

Figure 2.1 : Weather Data Collection in Durian Tunggal, Melaka 2023 [3]

2.3 Distillation Process

Distillation is the process of turning a liquid into a vapour, which is then condensed back into a liquid state. The simplest illustration of it is when steam from a kettle condenses into droplets of distilled water that are left on a cold surface. Distillation can be used to separate two or more liquids with different boiling points, such as the separation of petrol, kerosene, and lubricating oil from crude oil, or to separate liquids from nonvolatile particles, as in the separation of alcoholic beverages from fermented materials. Other industrial uses include the desalination of seawater and the processing of chemicals like formaldehyde and phenol.

The early experimenters appear to have used the distillation method. According to Aristotle (384–322 BCE), saltwater evaporates to create clean water. The crude method of condensation described by Pliny the Elder (23–79 CE) involves heating rosin to produce oil, which is then collected on wool put in the upper section of a device known as a still [4] .

Solar water distillation is the technique of removing salts or other impurities from freshwater using the energy of the sun. Untreated water slowly warms up to high temperatures as a result of absorbing heat. The impurities are left behind as the water evaporates, cools, and condenses into vapour as a result of the heat. Low capacity and independent water providing systems can employ solar stills.

The process through which a liquid turns into a gas is called evaporation. When a liquid's molecules take in enough energy to overcome the forces keeping them together and break free to become gas molecules, this phenomenon takes place. The method behind this is vapour pressure differences between a gas and a liquid. Temperature, humidity, and wind speed are a few variables that have an impact on how quickly water evaporates.

A gas can become a liquid through the process of condensation. A liquid is created when the molecules in a gas lose enough energy to overcome the forces holding them apart. This happens when a gas is converted into a liquid. The difference in vapour pressure between the gas and the liquid drives this process.

Condensation can be created purposefully, such as during the distillation process, or it can happen spontaneously, such when water vapour in the air cools and becomes dew or frost. Temperature, pressure, and the existence of condensation nuclei all have an impact on the rate of condensation. Figure 2.2 shows the example of evaporation process occurred in a hemispherical solar still.

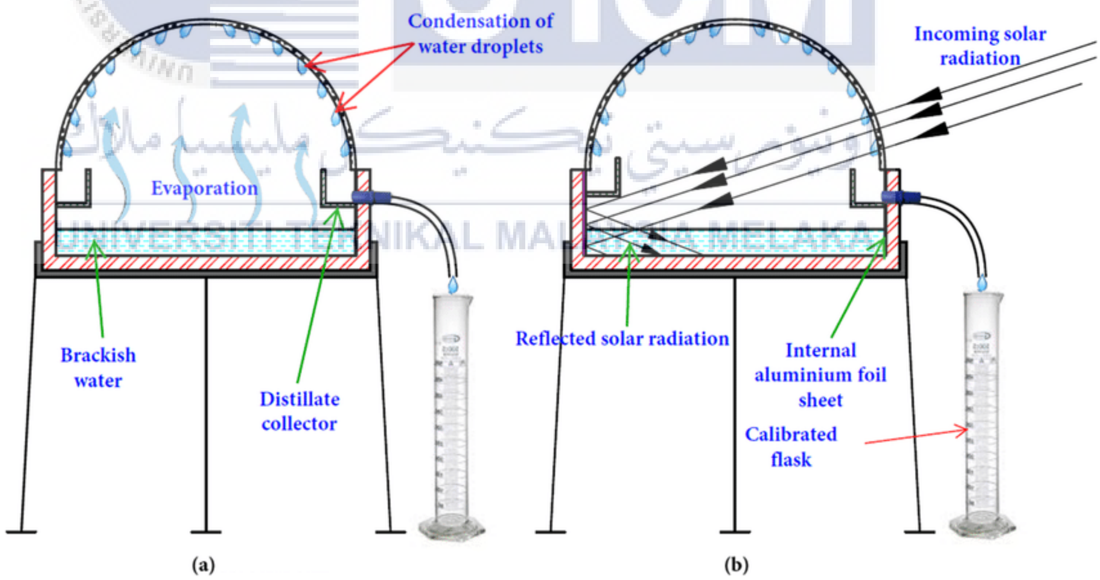

Figure 2.2 : Examples of Evaporation Process in Hemispherical Solar Still

2.4 Water Purification

The usage of traditional water purifying methods that depend on renewable energy sources is becoming more prevalent worldwide. Water is a basic necessity for all creatures, whether human and animal. alive on earth, especially in deserts, distant areas, and harsh climates. Over the past thirty years, a variety of solar still designs that boost freshwater production have emerged.

Removing undesired chemicals, biological contaminants, suspended particles, and gases are all steps in the purification process. It is necessary to create water that is acceptable for a variety of functions. For human use (drinking water), water is often cleansed and disinfected, but it can also be purified for a variety of other applications, including industrial, medical, and pharmaceutical ones. Through history, a wide range of techniques have been utilised to cleanse water. The activities involve both physical processes like filtration, sedimentation, and distillation as well as biological ones like slow sand filters or biologically active carbon.

2.5 Hemispherical Solar Still Design

Solar stills are essentially metallic basins with transparent covers, but they have some operational issues that limit their spread. For conventional designs, the small area of the glass cover compared to the basin area decreases the vapor condensation rate. Additionally, they frequently have one side towards the sun. Additionally, the glass over the basin's edge has a sharp edge that frequently results in losses in the distilled water collection. Since they can face the sun in any direction during the day, a new design with a hemispheric glass cover has been adopted in recent years to come over them. Additionally, the hemispheric cover form offers a broad condensation surface without any sharp edges. Moreover, the ambient air surrounds the cover better than the typical distiller's covers, providing good cover cooling which has a final better condensation rate [5] . The hemispherical solar still that was chosen is 40 cm as this is the biggest diameter of hemispherical dome cover in the market an it is corresponding to the previous research that shows that if the absorber radii is larger the efficiency and productivity increase simultaneously [6] . Figure 2.3 shows the hemispherical solar still design

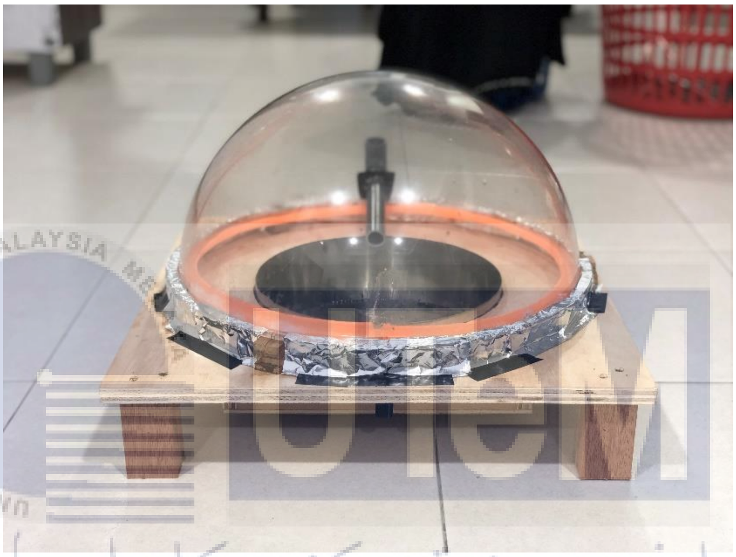

Figure 2.3 : Hemispherical Solar Still Design

2.6 Evaporation using Thermoelectric Heating (Peltier) and river rock effect

Evaporation is the process by which a liquid changes into a vapor. This process occurs when the molecules in a liquid gather enough energy to overcome the forces that keep them together in a liquid state. When this happens, the liquid turns from a liquid into a gas through a process called evaporation. At its surface, a liquid will evaporate; the rate at which this happens is dependent on several factors, such as the temperature of the liquid and the humidity of the surrounding air. Figure 2.4 shows the evaporation process [7] .

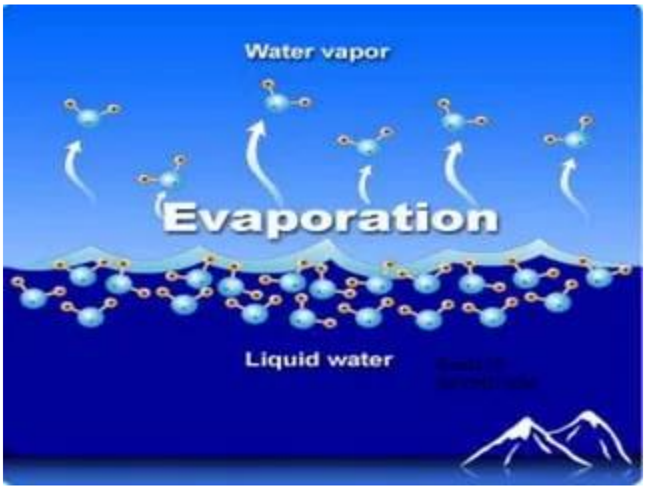

Figure 2.4: Evaporation process

Because the molecules have more energy and are more prone to leak as gasses into the environment when the liquid temperature rises, the rate of evaporation increases as well. Similarly, when air humidity decreases, there is less water vapor in the atmosphere to challenge the liquid for the energy that is available, which causes the rate of evaporation to increase.

The river rock was included in the experiment to increase the rate of evaporation of the water. Previous study shows an increment in temperature for the basin that more river rocks. Water temperaturate also become increases after the addition of more quantity of rocks. This shows that the river rock offer quite an effect for the increase in temperature. Next, the temperature of the inner and the outer glass of the hemisphere solar still of the previous research shows an increase trend [8] . Due to this effect and result, the river rock has been selected as one of factor in to enhance the productivity of clean water from the solar still. Figure 2.5 shows the examples of river rock that used for the project

Figure 2.5 : Sample Of River Rock

2.6.1 Thermoelectric Heating (Peltier)

The Peltier Effect is a scientific phenomenon that forms the basis of thermoelectric systems. This phenomenon states that when an electric current flows through the connections of two conductors, a temperature gradient is created. This action causes cooling to occur in one junction and heat to be deposited in the other. Although they are mostly employed in cooling equipment, thermoelectric systems are also found in heating devices. Figure 2.6 depicts the process of heating.

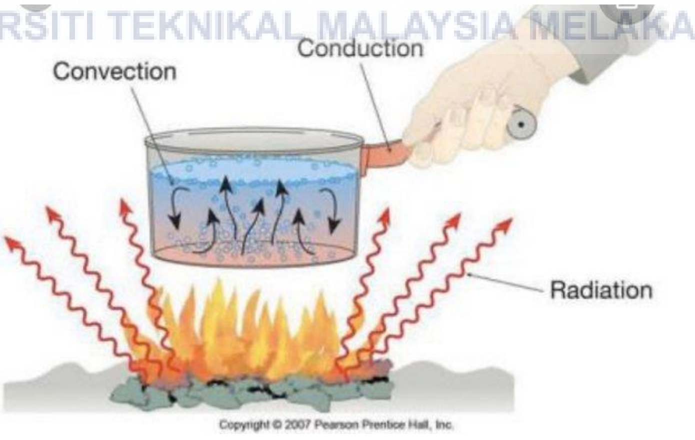

Figure 2.6: Heating process

Through energy absorption at one connector and release at the other, the conductors try to restore the electron equilibrium that was there before to the application of current. To increase the impact, the individual couples can be combined into a series. Since the direction of heat transfer is determined by the polarity of the current, changing the polarity of the current can alter the direction of heat transfer and reveal the amount of heat absorbed or evolved. A Peltier cooler/heater, a thermoelectric heat pump that moves heat from one side of the device to the other, is an illustration of the effect [10] .

Commonly Peltier effect devices sold on the market as thermoelectric Peltier TEC (thermoelectric cooling) were usually used in a small experiment to show how principle works, as computer cooler as the temperature can drop up to 0 degree Celsius making it suitable for computer with high performance. Figure 2.6 shows the Peltier effect in the peltier module.

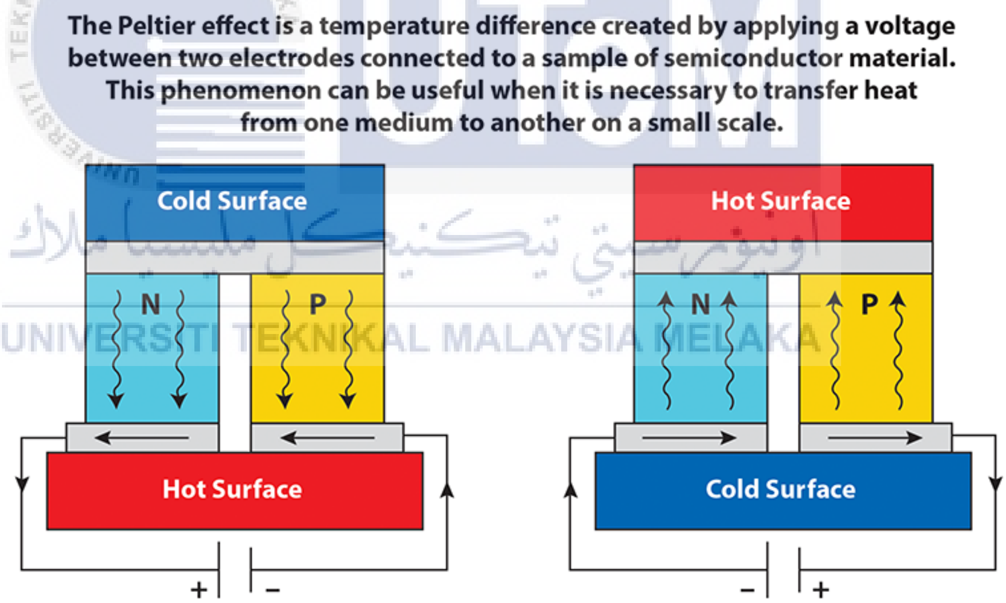

Figure 2.7 : Peltier effect

2.6.2 River rock effect in evaporation

When taking into account the river rock impact, evaporation is a fundamental process regulating water dynamics in natural environments exhibits fascinating subtleties. This phenomena is centered on the unique thermal characteristics of river rocks, which are essential for regulating the rates of evaporation in aquatic environments. River rocks provide the nearby bodies of water a distinct thermal signature because they function as thermal moderators, absorbing solar energy during the day and releasing it at night. As a result, surface water temperature changes over time due to the river rock effect, which affects evaporation rates during the day. Research have shown that depending on the surrounding environmental factors, this effect can either accelerate or slow down evaporation. Accurate water budget modeling requires a thorough understanding of the river rock effect, especially in areas with rocky riverbeds. The river rock effect is more significant than just its local impact on evaporation; it also affects climatic patterns, water availability, and ecosystem dynamics. The river rock impact creates obstacles for evaporation modeling but also provides opportunities for creative approaches to water management. It will take multidisciplinary research projects combining hydrology, geophysics, and climatology knowledge to overcome these obstacles. In summary, deciphering the nuances of the river rock impact advances our knowledge of evaporation dynamics and provides important new information for the sustainable use of water resources [9] . Figure 2.8 shows the example of river rock.

Figure 2.8 : Examples Of River Rock

2.7 Tap Water Quality in Malaysia

A thorough background investigation of Malaysia's hazardous tap water quality identifies a number of worrisome elements that have impaired the water's suitability for human use. First off, high concentrations of impurities have been found in a number of water sources, including heavy metals, microbiological infections, and chemical pollutants, which could endanger consumers' health. The issue is made worse by outdated water infrastructure, inadequate monitoring procedures, and inadequate water treatment facilities, all of which allow contaminants to seep into the water supply. Furthermore, there is a greater chance of pollutants getting into water sources due to the fast industrialization and urbanization of some places, which makes it difficult to maintain water quality requirements. Water safety education and public awareness campaigns are also important since consumer ignorance can lead to unintentional exposure to contaminated water. Given these complex factors, tackling Malaysia's dangerous tap water quality requires a comprehensive strategy that includes enhancing monitoring procedures, building new water treatment facilities, and launching aggressive public awareness campaigns. [13] One of the factor that made tap water isnt safe to consume is it is contaminated by old piping. Thus, hemispherical solar still has a solution to convert the unsafe tap water to safe pH level to be consume by the people.

2.8 Summary

In this chapter, the focus is on data gathering and theoretical aspects related to the project, aiming to define the functions of the process. The discussions will revolve around the various methods employed in solving the identified problems within the project. The review of the entire project encompasses three main areas. Firstly, it addresses the climate in Malaysia that caused the poor water supply, highlighting the importance of finding effective solutions. Secondly, it delves into the design of the Solar Still, which serves as the core component for water purification using solar energy. Lastly, it explores the utilization of evaporation techniques through the integration of Thermoelectric heating (Peltier) and the river rock effect, aimed at enhancing the efficiency and effectiveness of the purification process.

CHAPTER 3

METHODOLOGY

This chapter goes into great detail on the methods used to finish the project. It describes how the project was carried out to accomplish its objectives. This chapter also provides a summary of the project's methodology and the prototype's step-by-step construction. Additionally, each component used to create the prototype is extensively explored in terms of its functionality and operating philosophy. The procedures for putting each thing into practice in a prototype are also covered in this chapter.

3.1 Introduction

All the elements and theories that must be incorporated into the project have been determined based on the literature review. The process for creating the project will be thoroughly described and broken down into three sections, which will be detailed in the following subject.

3.2 Methodology of Work

The two primary hardware circuits for this project are the heating module and the solar still. The heating module will be attached to the galvanised water container within the solar still to heat the raw water to a certain temperature. The primary heating source is really direct sunshine; the heating module just serves as a support for this source. The block diagram for the temperature sensor used to measure water temperature is shown in figure 3.1.

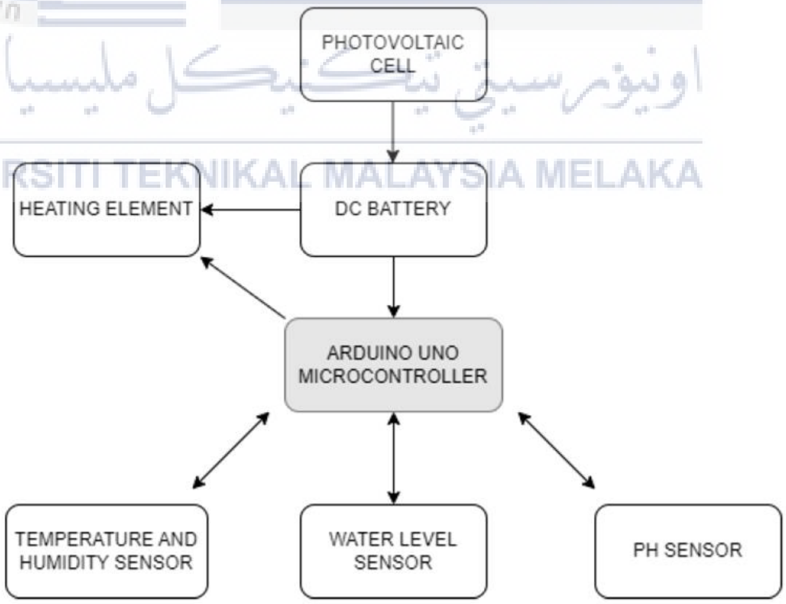

Figure 3.1 : Block diagram for the component used in the project

3.3 Project Development

Modelling Summary

Solar still has a variety of designs, each with advantages and disadvantages. The hemisphere type solar still has been selected as the design for the project; it will have a circular base, a height of about 19 centimetres [8}, an internal diameter of 40 cm and 42 cm of total diameter, all made of acrylic.The base of the solar still's early design may be seen below. The foundation of the solar still design is shown in Figure 3.2.

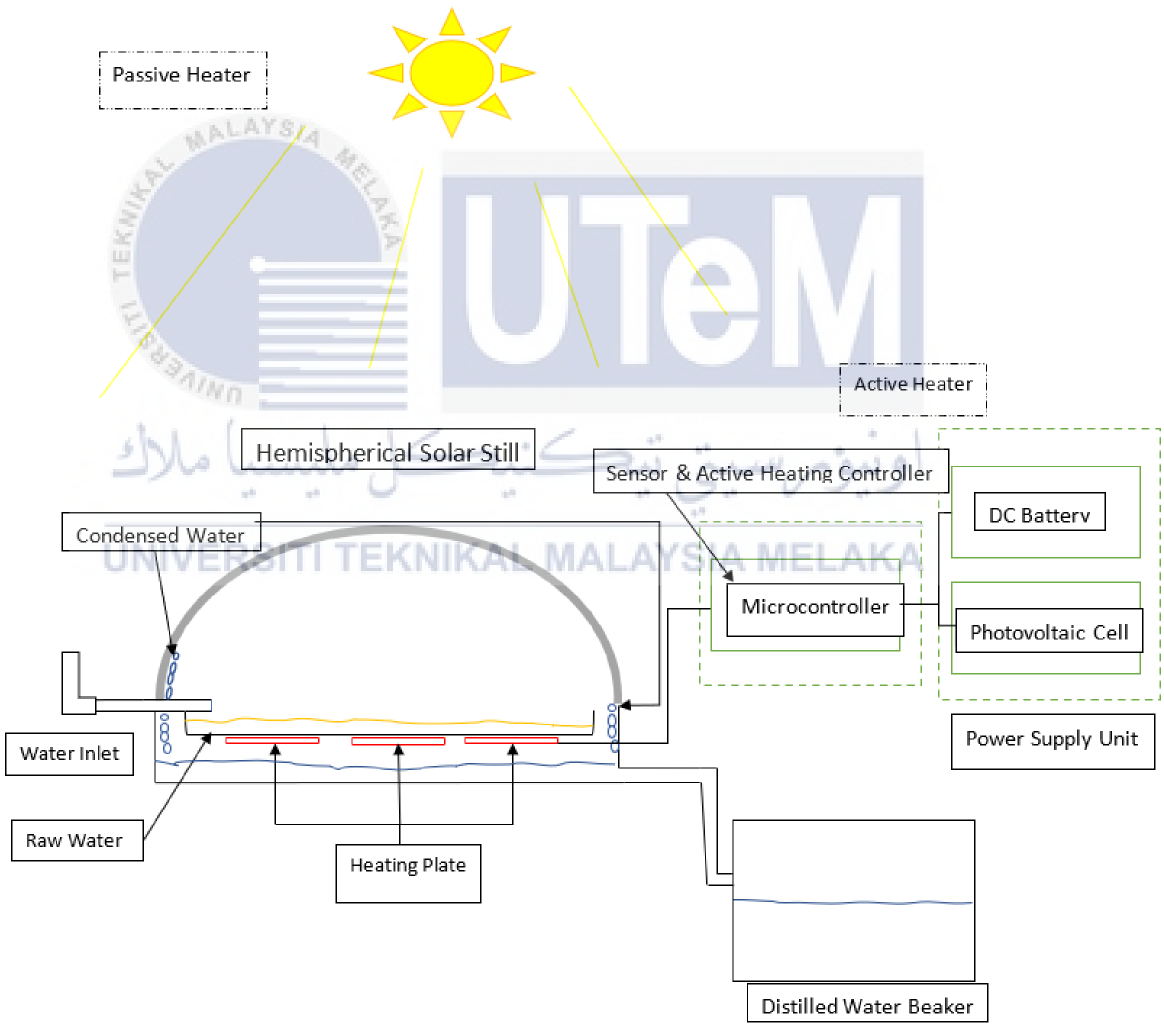

Figure 3.2 : Foundation of hemispherical solar still design

3.4 Hemispherical Solar Still Design

The current hemispherical dome cover that was chosen for this solar still is set at 40 cm in diameter. This specific radii of the top cover increase the effectiveness of the system by increasing the total surface area for the solar radiation, in which condenses the water in the solar still and conveniently cascades down to the edges of the solar still before ultimately collecting in the base. By utilizing the diameter of the solar still, we can maximize the water collection efficiency and improve the overall functionality of the solar still. Figure 3.3 shows the early stages of hemispherical solar still development.

Figure 3.3 : Hemispherical Solar Still Early Development

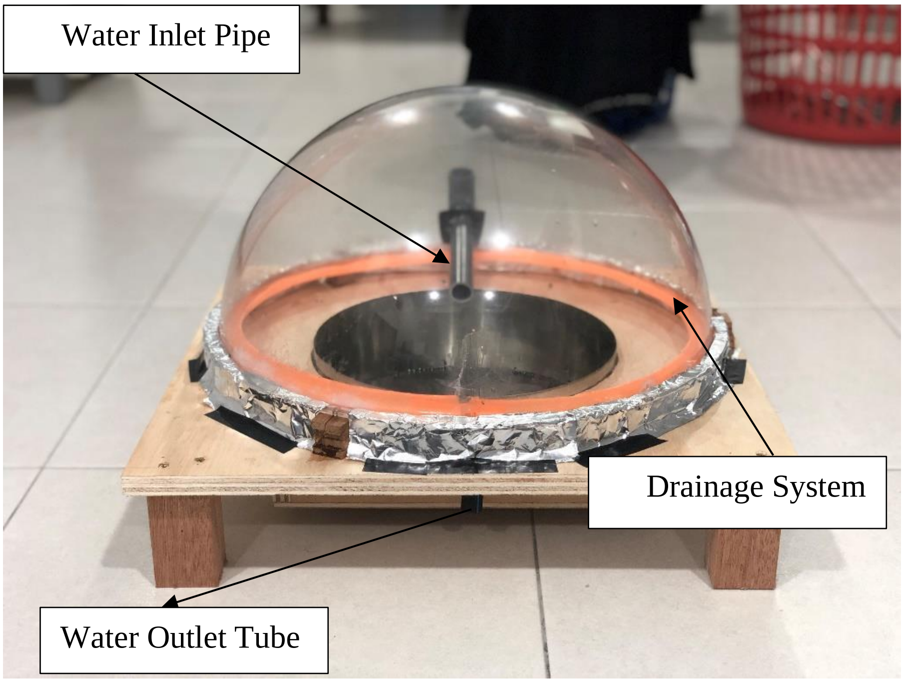

Figure 3.4 : Front view Hemispherical Solar Still Design

Figure 3.5 : Side view Hemispherical Solar Still Design

Figure 3.4 and 3.5 shows the completed design of hemispherical solar still. Water inlet system has been installed into the design to able the tap to be inserted in the hemispherical solar still. Water drainage system by using PVC pipe also has been attached to the hemispherical dome to enable the evaporated to drop and flow through drain connected and fall into the hole for the clean water collection. The aluminium foil used to cover the space between the hemispherical top cover and the base of the solar still.

3.4.1 Galvanized Steel

The solar still unclean water tank was constructed using galvanized steel sheets since they are readily available in the market and simple to work with the user only needs to bend and cut the material to make it useful. Aside from that, galvanized steel is one of the most often used steel varieties due to its prolonged durability, combining the zinc-iron coating's corrosion protection with the strength and formability of steel. By serving as a barrier against corrosive substances, the zinc shields the base metal, and the sacrificial nature of the coating produces a durable and superior steel product. The specifications for galvanized steel metal sheets are listed in Table 3.1.

Table 3.1 : Galvanized Metal Sheet Specification

Parameter	Specification
Type of metal	Zinc-Iron alloy
Method of fabrication	Cold rolled
Type of coating	Zinc-coating, hot-dip galvanizing
Surface finish	Mini spangle, smooth
Weight of zinc coating, g/m2	20
Thickness, mm	0.1- 0.8
Tensile strength, psi	58,000-79,800

Elongation, %	20.0
Yield strength, psi	36,300
Melting point, °C	650

Up to 392 °F, galvanized steel is suitable for high-temperature applications. The metal can tolerate temperatures as high as 80°C due to its high melting point, which makes it suited to survive harsh weather conditions outside on a hot day. Aside from that, the solar can still resist any harm because of its great tensile and yield strengths. [10]

3.4.2 Acrylic

Polymethyl methacrylate, or acrylic as it is scientifically known, is a clear, multipurpose plastic that is well-known for its remarkable optical clarity and light transmission. Acrylic is made by polymerizing methyl methacrylate monomers and has a special set of properties, such as being weather-resistant, impact-resistant, and lightweight but durable. Because of its simplicity of production and ability to be molded into a wide range of shapes, it is a material of choice for applications like optical lenses, architectural glazing, lighting fixtures, and signs. The material's adaptability to various surface finishes and hues also adds to its overall versatility in terms of aesthetics. Despite its generally strong chemical resistance, acrylic should be taken into account for certain applications. Acrylic is frequently utilized in a variety of industries, such as medical devices and aquariums, due to its qualities, which include optical clarity, durability and design flexibility.Table 3.2 shows rthe specificiation of the acrylic material.

Table 3.2: Acrylic Specification

Properties	Value
Material Grade	Optical grade
Color	Clear
Thickness	5 mm
Diameter	300 mm
Surface finish	High-gloss polished
Light transmission	92%
Tensile Strength	70 MPa
Flexural Strength	90 MPa
Impact Strength	$15 kJ/m^2$
Elongation at Break	40%
Coefficient of Thermal Expansion	70 x 10^-6/ ^{o}C
Heat Deflection Temperature	90 ^{o}C
Weatheribility	Suitable for outdoor use

Acrylic is a polymer that is made from methyl methacrylate and is preferred over glass in many applications due to its optical clarity. This lightweight material is ideal for applications ranging from protective barriers to signage because of its remarkable strength and impact resistance. Because acrylic comes in a wide variety of colors and surface finishes, designers have more creative freedom to achieve the ideal aesthetics. It is also appropriate for outdoor applications because to its UV resistance and simplicity of manufacture. Acrylic's many uses include architectural glazing, medical devices, and artistic displays. Its adaptable qualities make it a material of choice for people looking for a blend of durability, transparency, and design flexibility.

3.5 Circuit Design

A solar controller will be included in the configuration. By serving as a crucial bridge between the solar panel and the battery, this solar controller promotes effective energy use. Solar radiation is captured by the solar panel and transformed into electrical energy, which powers the battery's charging process. The battery's stored energy provides the electronic controller with a steady power source. Furthermore, in low light or at night, the solar controller is essential in preventing the battery from draining back into the solar panel.

When sunlight isn't available, this feature makes sure that the energy that has accumulated during the day is properly used and stored to power the system. The solar controller maximizes the setup's total energy efficiency by cleverly controlling the energy flow. The circuit design constructed in Fritzing software and the connection is shown in Figure 3.6.

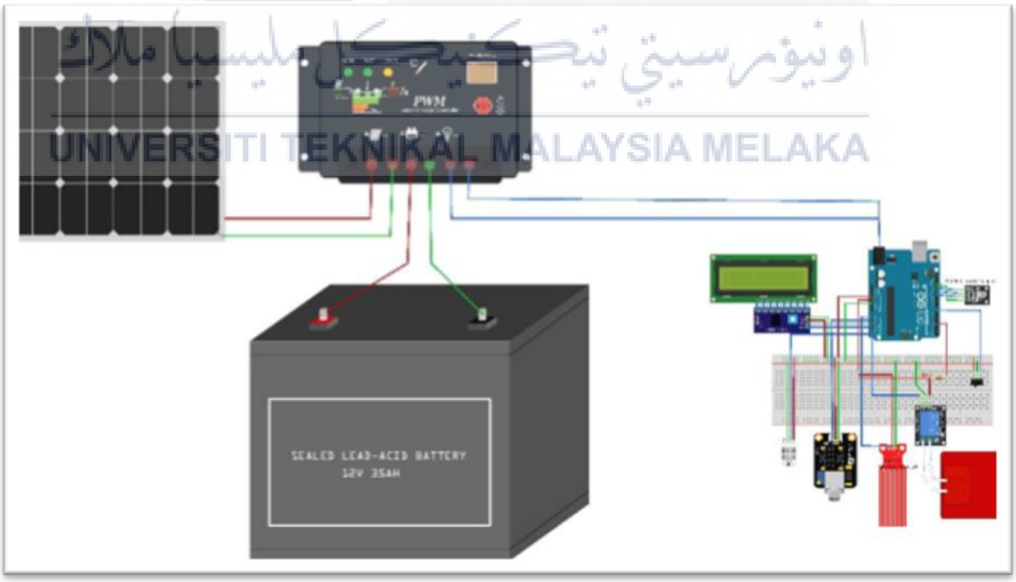

Figure 3.6 : Circuit Design Connection using Fritzing

With a 20 Watt power capability, the solar panel is specifically made to charge a 12 Volt DC battery. As an energy reservoir, this battery can hold enough power to keep the system running on cloudy or nocturnal days when solar irradiation is low. The system can sustain a steady power supply for the Arduino microcontroller, guaranteeing continuous functioning and control of every sensor, by employing a 12V DC battery.The Arduino microcontroller functions as the system's core controller, coordinating the operation of its many sensors. Numerous sensors, including Peltier devices, pH, water level, and humidity sensors, are connected to the Arduino. Every sensor is essential to the monitoring and control of many elements of the water purification process. The system allows efficient water purification process monitoring, control, and optimization through the combination of the solar controller, battery storage, Arduino microcontroller, and other sensors. By utilizing solar energy, this all-encompassing strategy guarantees dependable and sustainable operation, improving the efficiency and efficacy of obtaining clean and safe water.

3.5.1 12V DC Battery

The 12-volt battery is an interesting part that is used in many different specialized electronic applications. It has different features and looks depending on what it is meant to be used for. In contrast to traditional batteries, the 12-volt battery exhibits exceptional adaptability, providing a wide array of combinations and features to meet individual needs. Some of these batteries can be recharged, which allows customers to add more power to them for longer periods of use and more convenience. When considering solar power systems, the conversion of a 20-watt solar panel's output which is 20 watts at 12 volts into the domain of battery storage becomes a crucial factor. This corresponds to a value of around 2 Amps in terms of electrical current, which is the amount of power that can be efficiently gathered and stored in the battery. It should be noted that this number is an essential point of reference for comprehending the 12-volt battery's charging dynamics. Examples of 12-volt DC batteries are shown in Figure 3.7.

Figure 3.7 : 12 V DC batteries

In addition, in order to calculate how long the solar panel will take to fully charge a 12-volt, 12-amp battery, it is necessary to account for the amount of time the panel is exposed to sunlight. Assuming that the solar panel receives six hours of direct sunlight, it is clear that this particular duration is required for the solar panel to collect enough solar energy and direct it into the battery, thereby recharging its power reserves. This prolonged exposure to sunlight is essential for the charging process since it guarantees that the 12-volt battery stores and absorbs the maximum amount of energy, providing consistent power for a range of electrical uses. In the world of electronic applications, the 12-volt battery holds a unique place since it can be configured in a variety of ways to meet different needs. Its ability to be recharged adds to its usefulness and ease, making it an advantageous addition in a variety of settings. It is important to comprehend the relationship between the electrical current produced by a 20-watt solar panel, the amount of time needed to charge a 12-volt, 12-amp battery, and the complexity of effectively utilizing solar energy and optimizing its storage for continuous power availability.

3.5.2 Solar Panel 20 Watt

Using a solar panel, one can create electricity that can be used to power electrical loads from the sun's light, which is made up of energy particles known as "photons." In addition to producing electricity for use in household and commercial solar electric systems, solar panels can also be utilized for remote sensing, telecommunications equipment, and remote power systems for cabins. The operation of a 25-watt solar panel is similar to that of other solar panel sizes. 20 Watt solar panel example is shown in Figure 3.8.

Figure 3.8 : Example of 20Watt Solar Panel

Photons from the sun excite the electrons in solar cells of a panel when they are exposed to direct sunlight. It's direct current here. This is a fantastic gizmo that powers your batteries or appliances by converting direct current to alternating current. The benefits of a 20-watt solar panel are listed below, along with the specifications in table

3.3:

• Outstanding work in the sun

• The compact size makes installation simple.

• Voltage optimized for 12 volt power systems

• Compact and transportable.

Table 3.3: 20Watt Solar Panel Specification

Solar Panel Characteristics
Peak Power (Wp): 20W ± 3%36 (4×9)
Monocrystalline Solar Cells
Voltage at maximum power (Vmp): 18V
Current at maximum power (Imp): 1.11A
Open circuit voltage (Voc): 22.4V
Short circuit current (Isc): 1.4A
Power allowance range: ± 3%
Dimensions: 16.5 x 12.6 x 0.67 inches
Weight: 4.54 pounds

3.5.3 Solar Controller

Through effective energy flow management, the charge controller, a vital part of solar power systems assumes a primary responsibility for protecting batteries and solar panels. It serves as a watchful gatekeeper, keeping a close eye on the charging procedure and stepping in to prevent the batteries from being overcharged. The charge controller makes sure that electricity is turned off as soon as it determines that the batteries have achieved their maximum capacity by carefully controlling the energy flow. Batteries are essential storage units for the solar energy that is harvested in solar power systems. Nevertheless, negative outcomes like overcharging may occur if the solar panels' power output exceeds the solar battery's capacity. The overcharging issue might have a negative impact on the battery's general health and lifespan. Excessive current entering the battery might cause internal chemical reactions that shorten its lifespan and affect its performance. When the solar battery reaches a fully charged condition, the inverter and charge controller must act quickly to reduce these dangers. A functioning example of a solar controller is shown in Figure 3.9.

Figure 3.9 : Example of the Solar controller

At the point at which the battery is fully charged, the charge controller take over and manage the excess power produced by the solar panels. Their main goal is to manage and reroute the extra energy in a way that reduces hazards and increases effectiveness. The inverter and charge controller work together to efficiently distribute excess power to other parts of the system or to external loads, therefore preventing the batteries from suffering the negative effects of overcharging. The longevity and performance of the battery are protected, and the safe and efficient operation of the whole solar power system is ensured by this proactive intervention. In order to keep solar power systems balanced and intact, the charge controller is essential. It provides batteries and solar panels with protection by closely monitoring the charging process and avoiding overcharging. The charge controller, inverter, and solar battery work in unison to guarantee that surplus electricity is promptly and effectively managed. This reduces risks and protects the system's longevity and overall performance.

3.5.4 Arduino Uno

Because of its strong architecture centered around the ATmega328 microcontroller, the Arduino Uno is a microcontroller board that is incredibly feature-rich and versatile. It is an excellent starting point for a plethora of electronic projects. This robust board has a remarkably large number of components, such as its 14 digital input/output pins, six of which may be easily used as pulse width modulation (PWM) outputs, hence increasing the potential applications. The Arduino Uno also has six analog inputs, a 16 MHz crystal oscillator, a power jack, an ICSP header for programming, a USB connection for easy computer interface, and a reset button, completing a full feature set to support the microcontroller's operation. The Arduino Uno's remarkable user-friendliness is among its most remarkable features. It is fully furnished with all the necessary parts and wiring needed to run the microcontroller smoothly. To begin using the board, all that is required is to connect the Arduino Uno to a computer via a regular USB cable. This will allow for easy programming and data transfer. The Arduino Uno's adaptability to different power sources is further enhanced by its ability to run on a battery or an AC-to-DC adaptor. An operational Arduino Uno R3 is shown in Figure 3.10.

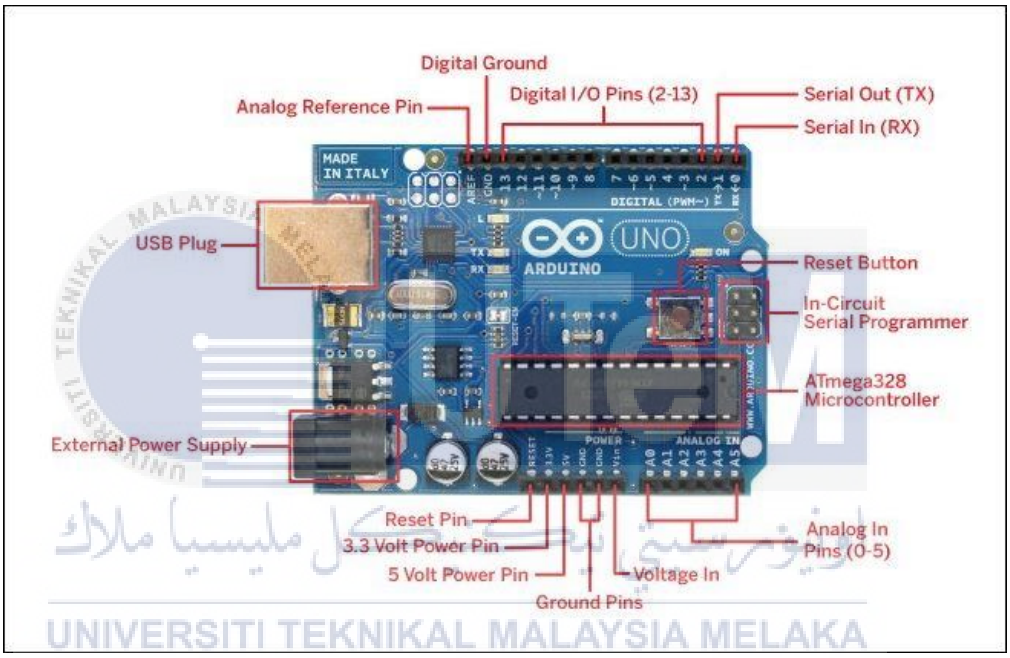

Figure 3.10 : Arduino Uno R3 with functions

The Arduino Uno is distinguished from its predecessors by a distinctive method of USB connectivity. The Arduino Uno features the Atmega8U2 microcontroller, which has been specifically designed to operate as a very efficient USB-to-serial converter, in contrast to previous boards that relied on the FTDI USB-to-serial driver chip. This creative design decision guarantees a hassle-free experience for consumers by improving the board's interoperability, dependability, and smooth integration with various operating systems. Making use of the Arduino Uno's amazing capabilities, a complex system for controlling and monitoring a variety of environmental conditions can be developed with it as a key component. The Arduino Uno serves as the core control unit, gathering, interpreting, and reacting to real-time data with accuracy by utilizing the power of compatible sensors, including temperature, water level, humidity, pH, and heating plate sensors. The Arduino Uno and the different sensors work together to create sophisticated environmental monitoring systems that offer insightful data and allow for accurate modifications based on the conditions being observed. Pin function of Arduino Uno R3 is shown in Figure 3.11.

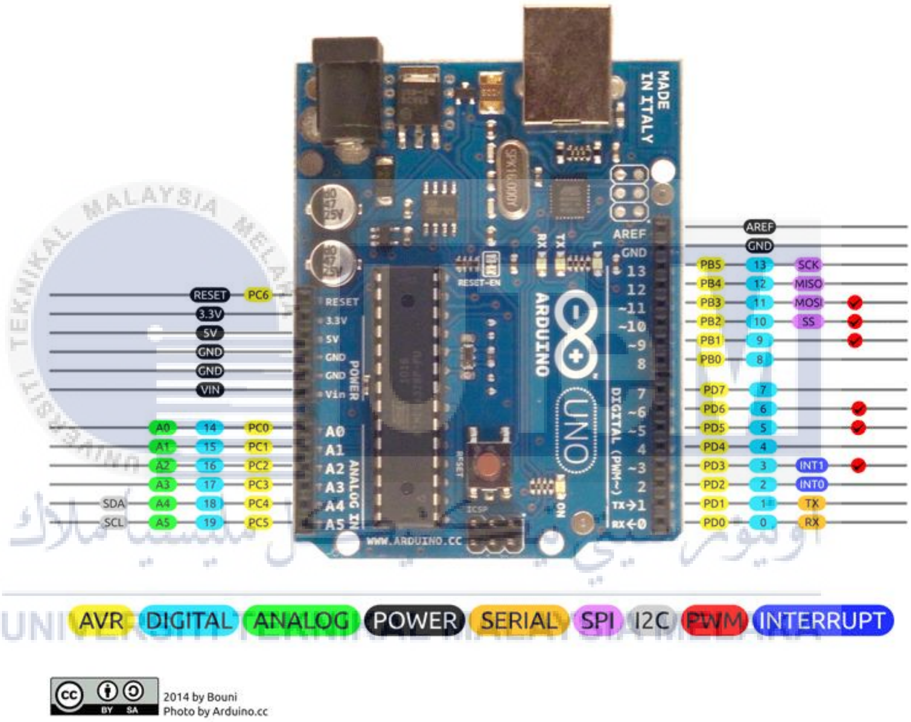

Figure 3.11 : Arduino Uno R3 Pin function

With a wide range of features and capabilities, the Arduino Uno is a microcontroller board that is both versatile and easy to use. It is the perfect option for a variety of electronic projects because of its extensive component suite and smooth USB interface integration with a computer. By utilizing the Arduino Uno's built-in strengths—such as its wide range of digital and analog input/output options and its creative USB-to-serial converter—one can build complex environmental monitoring and control systems that make use of numerous sensors to provide accurate and effective control.

3.5.5 Water Level Sensor

Accurately detecting and monitoring the liquid level in a stationary container is a critical function of the water level sensor, an indispensable part in many applications. Whether it's necessary to identify dangerously low or excessively high liquid levels, this adaptable sensor guarantees accurate and consistent observations. Through the use of a contact measuring technique, the liquid level's height is efficiently converted into an electrical signal that can be easily used for output. Because of its remarkable precision and performance, this water level sensor also referred to as the input type water level transmitter has become quite popular and is used in many different sectors and industries. Fundamentally, the purpose of the level sensor is to precisely monitor and measure liquid levels in a variety of applications. Its operation depends on how quickly it can identify variations in the liquid's level and transform the information it senses into a tactile and instructive electrical signal. This signal functions as an essential indication, providing the linked electronic system or control unit with critical information regarding the liquid level. Thus, the level sensor is essential to precise control over liquid levels and real-time monitoring, which helps ensure the safe and effective operation of various systems and processes. Examples of water level sensor pins are shown in Figure 3.12.

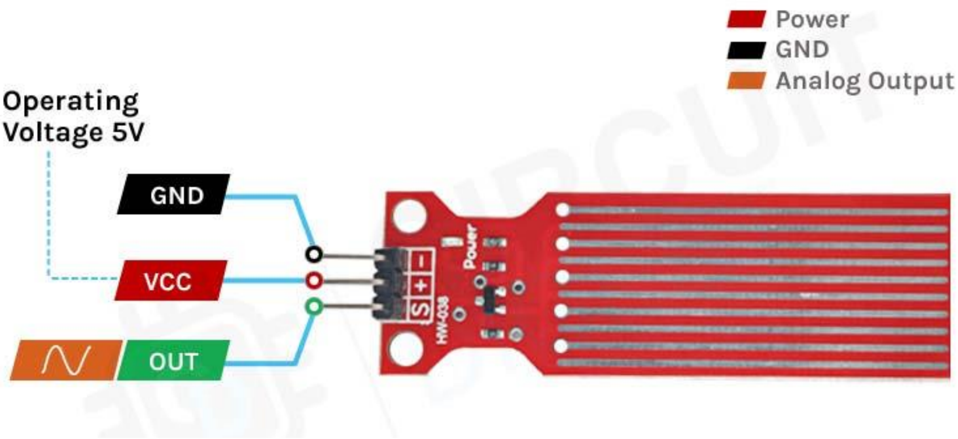

Figure 3.12 : Example of Water level Sensor pin

Another benefit that the water level sensor provides is that it works with the Arduino IDE. Programming the sensor to meet particular user needs becomes a simple and efficient process when it has an integrated library. This adaptability increases the sensor's versatility and adaptability in a range of applications by enabling customers to customize its functioning to meet the specific requirements of their projects. Furthermore, the water level sensor is widely available in the market, meaning that both individuals and companies can easily use it. This accessibility guarantees procurement simplicity, facilitating the sensor's smooth incorporation into projects and enhancing its appropriateness for a multitude of applications. Specifications for water level sensors are shown in Table 3.4.

Table 3.4 : Water Level Sensor Specification

Parameters	Specification
Operating Voltage, V	5
Working Current, A	20m
Sensor Type	Analog
Detection Area, mm	40x16
Working temperature, °C	10-30
Operation Humidity, %	10-90non-condensing

When it comes to measuring and keeping track of liquid levels, the water level sensor becomes an essential instrument. By utilizing its contact measurement method, it consistently translates liquid height into electrical signals, enabling precise and timely measurements. Programming the sensor to comply with particular user needs is made simple by the Arduino IDE's built-in library. In addition, the sensor's broad market availability increases its attractiveness and feasibility for various projects and applications, guaranteeing its applicability for a wide range of use cases.

3.5.6 pH Sensor

The pH sensor is a vital tool that is frequently used to measure the alkalinity and acidity of water and other solutions. It plays a crucial function in providing an accurate assessment of these values. This multipurpose sensor is a priceless instrument that guarantees the security and caliber of goods while enabling effective process monitoring in a variety of settings, such as manufacturing facilities and wastewater treatment plants. functioning in compliance with set protocols, pH sensors are essential for preserving ideal circumstances and averting possible dangers brought on by unbalanced pH levels. The pH scale, which normally ranges from 0 to 14, is essentially a basic reference point for determining how acidic or alkaline a thing is. Neutrality, or a pH of seven, is a balanced state in which neither acidity nor alkalinity predominates. The pH value provides information about the relative amounts of acidity or alkalinity present as it varies from this neutral point. Materials with pH values greater than seven indicate a greater level of alkalinity, whereas those with pH values less than seven are often more acidic. For example, commonplace products like toothpaste typically have pH values between 8 and 9, which indicates that they are somewhat alkaline. In contrast, stomach acid, which is an integral part of digestion, has a much lower pH value of two, which emphasizes that it is extremely acidic. A pH sensor examples are shown in Figure 3.13.

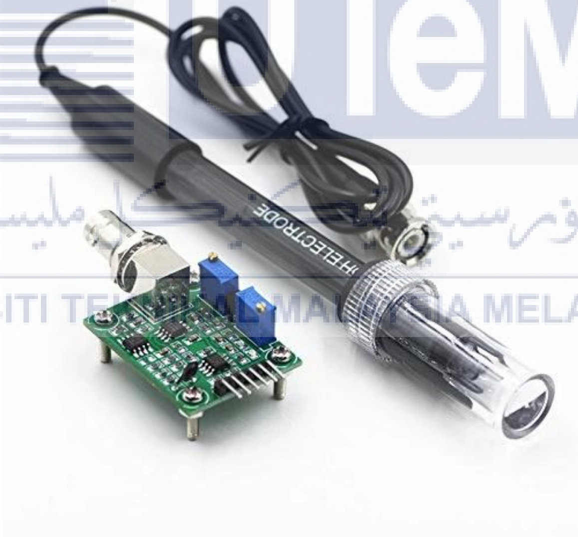

Figure 3.13 : Ph sensor

Precise measurements and pH level monitoring are made possible by utilizing the capabilities of pH sensors, which facilitates efficient quality control and regulatory compliance in a variety of sectors. With the use of this sensor technology, experts can ensure that crucial parameters are within specified limits and minimize potential risks connected with imbalanced pH levels by making well-informed judgments based on real-time data. These sensors help to optimize operations, safeguard the integrity of products, and prevent negative consequences that can result from severe or uncontrolled pH conditions because of their capacity to detect even minute changes in pH levels. The pH sensor specifications are shown in Table 3.5.

Table 3.5 : pH sensor description

Parameters	Specification
Measuring range	0-14 pH
Accuracy	±0.1 pH (25°C)
Response time	≤1 min
Measuring temperature	0-60°C

In the field of water measurements, the pH sensor proves to be an invaluable instrument, providing accurate indications of the levels of acidity and alkalinity in solutions. Among other things, its use guarantees the effectiveness, safety, and quality of operations in industrial and wastewater treatment plants. This sensor allows for the accurate determination of pH values, indicating the relative acidic or alkaline nature of things, by functioning within the defined pH scale. Professionals may make well-informed decisions, put in place efficient control mechanisms, and maintain ideal conditions in a variety of applications by receiving critical insights on pH levels. This ultimately improves safety, quality, and performance.

3.5.7 Humidity Sensor (DHT 11 Sensor)

The amount of water in the air is known as humidity, and it has a major impact on a variety of physical, chemical, and biological processes. The amount of water vapor in the atmosphere has an impact on many elements of our environment, from the productivity of industrial processes to the development and survival of creatures in various habitats. Specialized sensors called humidity sensors are used to detect and react to changes in the air that may affect electrical currents or temperature in order to precisely measure and monitor humidity levels. When referring to moisture in a more general sense, it includes the amount of water present in any kind of material or substance. On the other hand, by referring the word precisely, "moisture" refers to the amount of water that is in both solids and liquids. Conversely, "humidity" relates only to the amount of water in gases, most notably the air we breathe. Thermal sensors are a prominent class of humidity sensors that are mostly used for measuring absolute humidity (AH). These sensors are especially useful in situations where accuracy and endurance are critical, such as in hot or corrosive environments. To measure this parameter the sensor that is very suitable to capture humidity and temperature of certain environment is DHT 11 sensor. Humidity sensor DHT11 samples are shown in Figure 3.14.

Figure 3.14 : DHT 11 sensor

This humidity sensor uses two sensors to measure the humidity of an environment: one is a thermal sensor that measures the humidity of the surrounding air, and the other is a sensor that is securely enclosed in a dry nitrogen atmosphere. This arrangement makes it possible to measure humidity levels precisely, taking into consideration outside influences and guaranteeing reliable results even in difficult or unfavorable circumstances. These humidity sensors enable thorough and dependable monitoring of humidity levels by utilizing multiple sensors and strategically regulating the environment in which they operate. This promotes a deeper comprehension of the surrounding atmospheric conditions and their potential impact on a variety of applications. The amount of water in the air, or humidity, has a significant impact on a variety of processes. When it comes to accurately measuring and tracking humidity levels and identifying changes that may have an impact on electrical currents or air temperature, humidity sensors are an invaluable instrument. Humidity particularly relates to the amount of water in gases, whereas moisture normally refers to the amount of water in solids and liquids. This highlights how important it is to precisely measure atmospheric conditions. One type of humidity sensor called a thermal sensor is useful for determining absolute humidity, especially in harsh conditions with high temperatures or corrosive materials. These humidity sensors offer accurate measurements and facilitate thorough monitoring of humidity levels by carefully positioning sensors and establishing controlled environments. This improves our comprehension of atmospheric conditions and their consequences in a variety of disciplines. Sensor specifications for humidity are shown in Table 3.6.

Table 3.6 : DHT 11 Sensor Specification

Sensor Model	DHT11
Voltage	+5V
Input	Temperature and humidity in surroundings
Output	Digital Signal
Units	Temperature in celsius and humidity in percentage

3.5.8 Temperature Controller

An apparatus that controls and maintains a particular temperature in a system or process is called a temperature controller. Its main job is to take a target object or environment's temperature and compare it to a setpoint temperature that is wanted. To determine the current temperature, the temperature controller uses a temperature sensor, such as a resistance temperature detector (RTD) or thermocouple. An example of a temperature controller is shown in Figure 3.15.

Figure 3.15 : Temperature Controller

The temperature controller can be preset with the setpoint, or desired temperature. The setpoint can be modified by the user to the application's preferred temperature. Certain temperature controllers come equipped with built-in alarm features that notify users when the temperature rises above predetermined levels. In order to safeguard the system and avoid overheating, additional safety features like failsafe systems or high-temperature cut-off switches may be added. Specifications for temperature controllers are shown in Table 3.7.

Table 3.7 : Temperature Controller Description

Parameters	Specification
Temperature Range, C	-50°C to 200°C (-58°F to 392°F)
Sensor Type	RTD or thermistors.
Temperature Control Accuracy	±0.1°C or ±1%
Output Control	Analog output
Input Voltage	12V DC
Display	LED

3.5.9 Peltier

A key component of the project at hand is the thermoelectric system, a sophisticated configuration made up of two separate parts: the cooling side and the heating side. The thermoelectric device chosen for this particular system is the TEC1-12708, which is well-known for its exceptional capacity to produce heat and cold on opposite sides, which makes it a perfect fit for the intended configuration. The hot side of the Peltier module displays a notable increase in temperature, up to an astounding 25° Celsius when powered by 12V. On the other hand, the hot side can reach as high as 50°C when the operational voltage is raised to about 14v, demonstrating the device's remarkable heating capabilities. On the other hand, the thermoelectric system's cooling side reaches 0° Celsius, allowing for effective cooling processes. In addition, there were two peltier of this kind that was used in the project. Thus, making it quicker to heat the galvanised steel. This remarkable temperature range is more than enough to start the boiling process that turns water into water vapor. As a result, the thermoelectric system helps to convert liquid water into its gaseous state by creating the ideal vaporization conditions with its well planned heating and cooling sides. Peltier is used as an example in Figure 3.16.

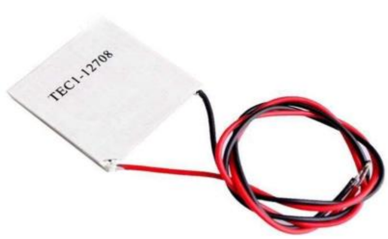

Figure 3.16 : Peltier Module

The thermoelectric system, which has separate heating and cooling sides, is an essential part of the project's assembly. By utilizing the TEC1- 12708 Peltier module, which is well-known for its capacity to produce heat and cold simultaneously, the system reaches impressive temperature ranges. The Peltier specification is displayed in Table 3.8.

Table 3.8 : Peltier Module Specification

Parameter	Minimum Value (S.I)	Maximum Value (S.I)
Hot Side Temperature, °C	25	50
Cold Side Temperature, °C	10	0
Q Max, W	71	79
Delta T max, °C	66	75
I max, A	8.5	8.4
V max, V	15.4	17.5
Module Resistance, Ω	1.50	1.80

3.6 Evolution of Hemispherical Solar Still Design

The many factors utilized in the creation of solar still designs are outlined in Table 3.9. These characteristics are used to ensure the robustness of the structure for long-term durability, maximize the efficiency of vapor formation, and achieve optimal evaporation and condensation performance. By carefully weighing these aspects and their interactions, designers may maximize the functioning of the solar still, improve water vapor generation, and create a sturdy structure that can sustain a variety of operating situations.

Table 3.9 : Early and Current Design of Hemispherical Solar Still

Design	Description
 **Design 1**	• Low Efficiency • The evaporation process happen but slow • Only small amount of vapor form • No drainage system
 **Design 2**	• Some of the space exposed causing inefficiency in heating. • Addition of water drainage system.
  **Design 3**	• The spaces exposed covered with aluminium foil to trap more heat. • Efficiency increases. • Drainage system completed.

The problems with the evaporation process cause insufficient vapor generation, which in turn causes low efficiency in a solar still. This is influenced by various factors, including the hemispherical solar still's design, radii of its surface, exposure to sunlight, and ambient circumstances. By recognizing and resolving these issues, efficacy in water filtration is increased.

3.6.1 Thermoelectric (Peltier+ Temperature Controller XH-W3001) and Microcontroller Setup

Peltier is the active heater in this project. It was arranged and connected by using series circuit to enable it to operates in the same voltage needed which is 12 V to be functioning properly, The 2.5 mm wire cable also used to connect the battery with temperature controller that also requires 12 v to activate. 1.5 mm cable cannot be used as it cause an overheat reaction when the peltier is connected at the output of the temperature controller. This maybe because of the total ampere in the circuit cannot be handle by the 1.5mm cable. The two peltier was place below the galvanised steel tank in order to heat the water in the tank. Figure 3.17 shows the position of the peltier module in the solar still.

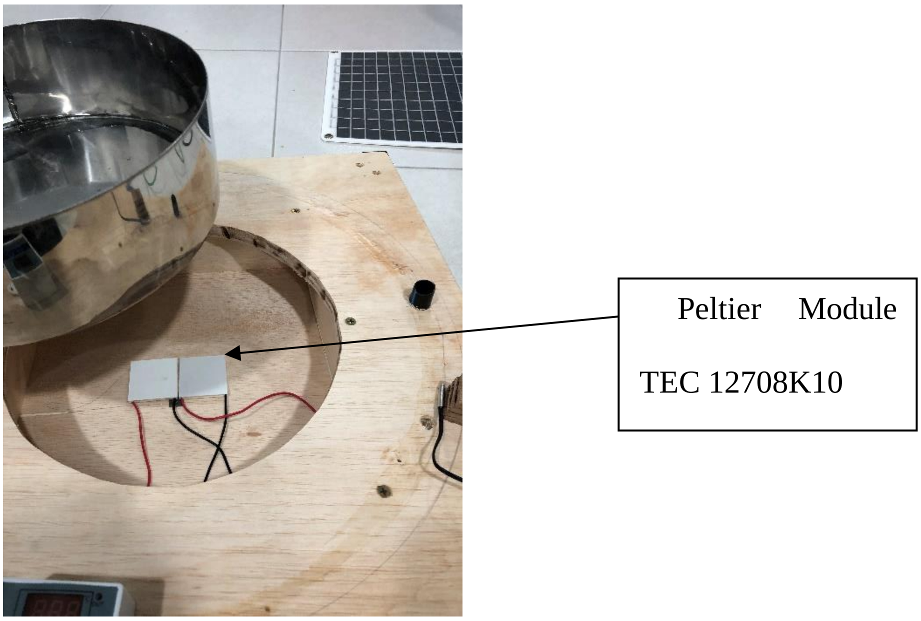

Figure 3.17 : Peltier Module in Solar Still

After the peltier has been installed, the the temperature controller also has been connected as the output of the temperature controller as this device will be the moderator or controller of the temperature in the solar still. The start and stop temperature can be set by using this controller for the peltier to be functioning during the low temperature. Figure 3.18 shows the temperature controller location at the solar still meanwhile figure 3.19 shows the microcontroller setup and battery for the hemispherical solar still.

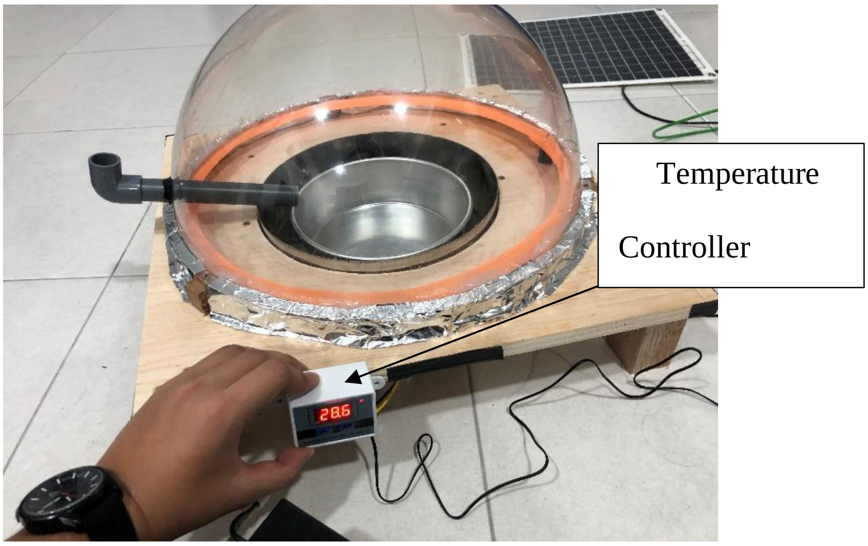

Figure 3.18 : Temperature Controller At Solar Still

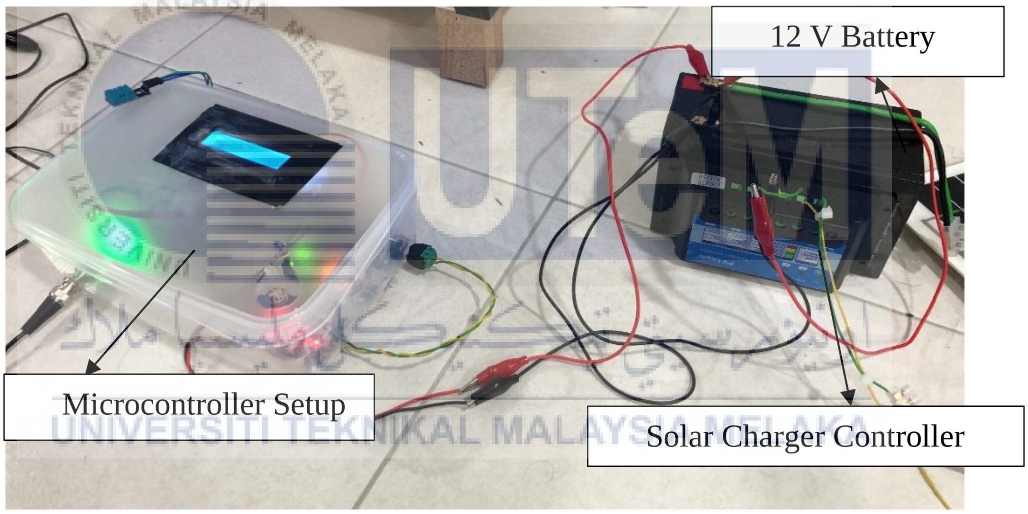

Figure 3.19 : Microcontroller Setup and Solar Charger Controller

3.7 Summary

Further methods, like the use of galvanized steel, river rock effect, and thermoelectric heating with Peltier devices, will be added to increase the rate of evaporation. These techniques seek to maximize evaporation efficiency and raise the output of potable water. Tests for pH values will be used to assess the produced water's purity; a pH of 6.5 to 7.5 is the ideal range for deeming the water suitable for ingestion. In addition, the adequacy of the clean water flow will be assessed over the course of a 7-hour testing period using a minimum threshold amount of roughly 100ml. Numerous sensors, such as pH, water level, and DHT sensors for temperature and humidity, will be used to guarantee accurate monitoring and management. These sensors will record and evaluate real-time data. To guarantee efficient control of the purifying process, an Arduino microcontroller will be used to coordinate and regulate the system.The design for the water inlet and drainage became some challenge to properly plan and excecution.

CHAPTER 4

RESULTS AND DISCUSSION

This chapter will test the project to determine the hemispherical solar still's performance and compare it to a system that uses a thermoelectric generator without river rock. Temperature, humidity, and the amount of sunlight that a hemispherical receive in order to achieve the optimal evaporation and condensation process are the parameters that need to be experimented with. To demonstrate to the solar still how effective the thermoelectric system is, the data will be entered into a table and examined.

4.1 Performance Analysis

An evaluation of a hemispherical solar still's efficiency and effectiveness in producing water, as well as its rate of water quality, is part of its performance study. A hemispherical solar still's efficiency is frequently evaluated by looking at how much water it can produce. It speaks of the volume of cleaned water produced in a given amount of time. This rate is dependent on a number of variables, including the still's size and design, humidity, temperature, and amount of sunlight factor. One major component influencing the pace of water creation is solar radiation. The water in the still is heated by sunshine, which speeds up the evaporation process. In sunny climes or during the hottest parts of the day, higher amounts of solar radiation lead to higher heat input and, as a result, higher rates of water production. However, the overall performance can be affected by changes in the seasons, location, and daily variations in solar radiation. Testing for a hemispherical solar still is shown in Figure 4.1.

4.1.1 First Test HSS (Hemispherical Solar Still + Tap Water Only)

Figure 4.1 : Testing For Hemispherical Solar Still

The rate of evaporation is influenced by the ambient temperature. In general, faster evaporation is encouraged by higher temperatures, which increases the amount of water produced. The air's humidity content has an impact on the evaporation process. Because there is a greater difference between the moisture content of the water and the surrounding air, lower humidity levels accelerate evaporation rates. Figure 4.2 depicts the process of evaporation.

Figure 4.2 : Process of Evaporation Occurred

4.1.1.1 Addition Of Dirty Water into the Solar Still

The galvanized steel container holds the collected unclean water source. Because of the bacteria and dust in the tap water, its pH of 9.00 is not appropriate for the pH of 7 in clean water. Both before and after the evaporation process, the data was gathered. The tap water source configuration is depicted in Figure 4.3.

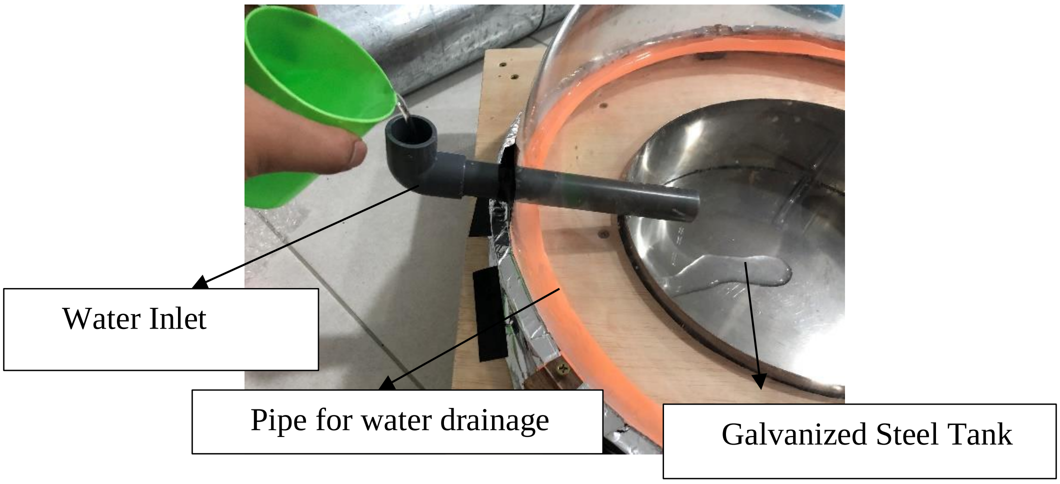

Figure 4.3 : Insertion of Tap Water In Solar Still

By referring figure 4.4 below, it shows the first’s test collected clean water from the experiment. The test ran for 6-hour test from December 16 2023 until December 19 2023 as it requires 4 test thus there is 4 days, from 12:00 PM to 6:00 PM. hourly logs were kept to track the process's development. Over the course of the experiment, the water gradually evaporate and turn into water vapors that collected on the hemispherical surface. The condensed water vapor had a much cleaner composition and a pH value that was almost seven when it is collected in a container. This was in sharp contrast to the initial unclean water. The sun's radiant radiation, which wasd used as a crucial component in the experiment, was the main cause of this evaporation phenomenon. Test 1's outcome is displayed in Table 4.1.

Figure 4.4 : Clean Water Collected from Test 1

Table 4.1 : Test 1 Result

Time / Parameter	12:00 am	1:00pm	2:00pm	3:00 pm	4:00pm	5.00pm	6.00pm
Temperature	34°C	34.2°C	34°C	33.8°C	33.6°C	33.4°C	33°C
Humidity	70%	69%	71%	71.6%	72%	73%	74%
Clean Water Level (ml)	None	None	Start to drop	10	15 (Low)	20 (Low)	22 (Low)
Water Quality	8.50pH	None	None	None	7.25pH	7.24pH	7.24pH

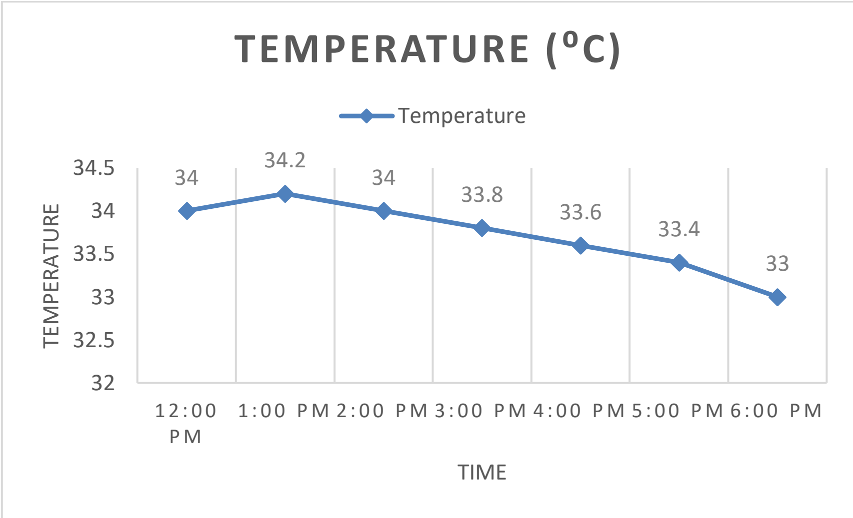

Figure 4.5 : Graph of Temperature In Solar Still For Test 1

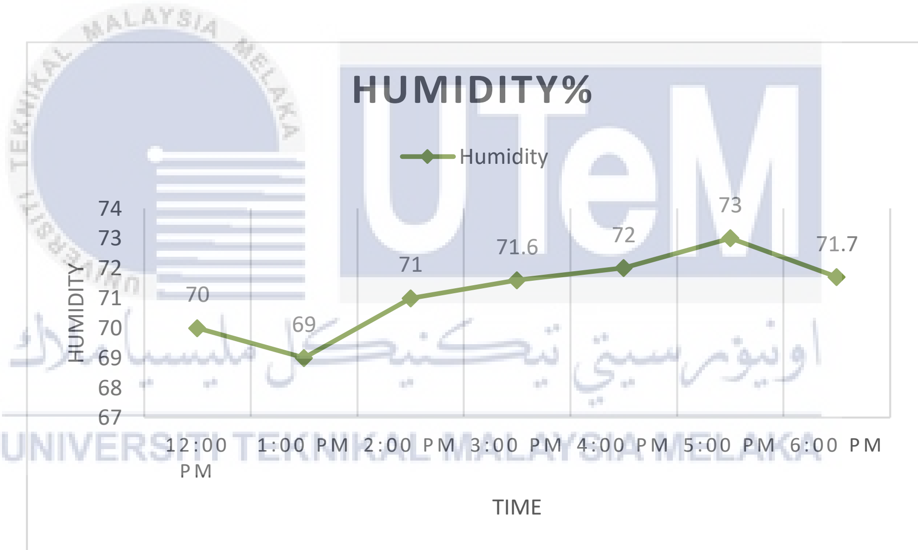

Figure 4.6 : Graph of Humidity in Solar Still For Test 1

From the result of test 1, it can be observe that the temperature in the solar still revolves around 32-34 degree celcius. This shows that this is the normal temperature from solar radiation of sunlight. Meanwhile, the humidity that was recorded between 12:00 pm to 6:00 pm during test 1 is regulated between 71 till 74% in humidity. This shows that when the temperature is high the humidity of the environment is also become high as the evaporation occurs. By time the heat stored in solar still makes the evaporation process occurs causing the humidity to increase and water droplet increases with time. But the humidity in the first hour is not high because the evaporation may not occur yet due to water need to be in certain environment that meet the temperature level for the evaporation to occur. The water collected in this test is not high in volume but reach the main objective of this test which is getting the good value of pH which is 7.24 in value from 8.50 pH value of the tap water before the test.

4.1.2 Second Test (Hemispherical Solar Still + Tap Water + River Rock) (HSSRR)

River rock used in this experiment to increase the longetivity of heat an temperature in the solar still throughout the experiment, The heat stored in the river rock increase the longetivity of heat in the solar still and causing the evaporation process continue even there is slightly low heat. Figures 4.7 show the testing for river rock test.

Figure 4.7 : Test 2 HSSRR Setup

The first step was to mix the collected unpurify water with a precisely determined amount of river rock to see how well the evaporation process worked with the help of sun radiation. The transforming effects of evaporation were investigated using this mixture as the experimental medium. In order to guarantee thorough observation and gathering of data, DHT will be identifying and documenting the current humidity levels as well as the surrounding temperature within the hemispherical solar still. Four liters of contaminated water were put in a galvanized container along with 200 grams of river rock. This intentional combination acted as the foundation for the methodical evaluation of the water's quality, which involved comparing the pH values that were discovered. Test 2 results are displayed in Table 4.2. Figures 4.8 and 4.9 display the test 2 temperature and humidity graphs.

Table 4.2 : Test 2 Results

Time / Parameter	12:00 am	1:00pm	2:00pm	3:00pm	4:00pm	5.00pm	6.00pm
Temperature	40°C	37°C	36°C	36°C	35.5°C	35C	35°C
Humidity	69%	69%	70%	71%	72%	72%	72%
Clean Water (ml)	None	None	10	20	22	39	50
Water Quality	9.00pH	None	None	None	7.28pH	7.27pH	7.27pH

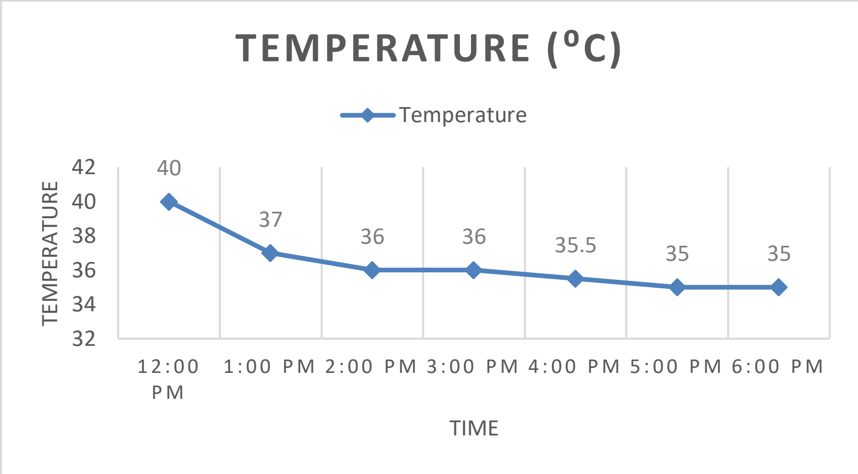

Figure 4.8 : Graph of Temperature In Solar Still For Test 2

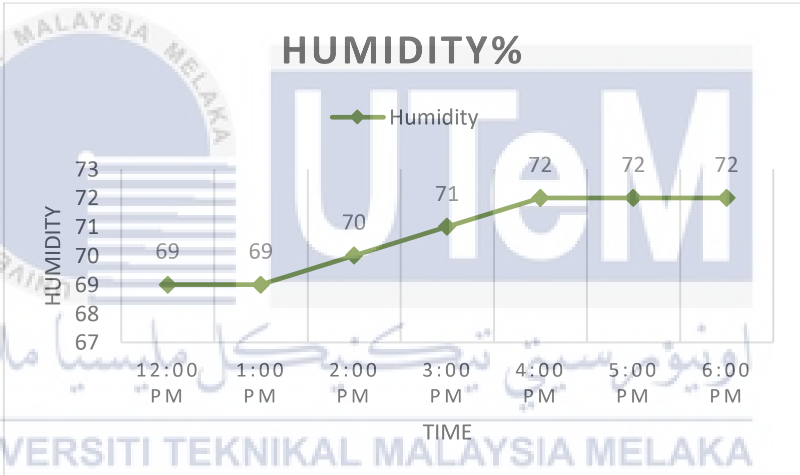

Figure 4.9 : Humidity In Solar Still Graph For Test 2

In comparison to test 1, the test table indicated that the inclusion of river rock increased the temperature. The temperature began to rise, just like in Test 1, but there was a noticeable difference: when river rock was added, the temperature rose. Because river rock may retain heat from the sun and raise the temperature of the inner solar still, this study shows that river rock has a major impact on the surrounding temperature. It's crucial to notice, that river rock also has an impact on the water's pH. When the pH of the clean water produced by the evaporation process was tested, it was found to be it was slightly lower in pH than the results of test 1. This suggests that the pH of the water is impacted by the presence of river rock. What was notable, in spite of this small variation, was the clean water was produced more than in test 1 which is 50 ml in total. These results highlight how important it is to take into account a variety of parameters and how they interact while researching the evaporation process.

4.1.3 Test 3 (Hemispherical Solar Still + Tap Water + Peltier) (HSSP)

In this experiment which is Test 3, incorporates the integration of a Hemispherical Solar Still with a Peltier device in conjunction with tap water, aiming to investigate the effectiveness of this combined approach in enhancing the evaporation and distillation processes. The introduction of the Peltier device is expected to amplify the heat transfer mechanisms, thus potentially improving the overall efficiency of freshwater production from the solar still, particularly when confronted with the challenges of treating contaminated water. This experimental setup seeks to assess the feasibility and performance of utilizing Peltier technology as a supplemental factor for enhancing evaporation and distillation in solar desalination systems, addressing both energy efficiency and water purification considerations. . Figures 4.10 and 4.11 show the setup for Peltier and power supply. Next figure 4.12 shows the temperature and humidity during test 3.

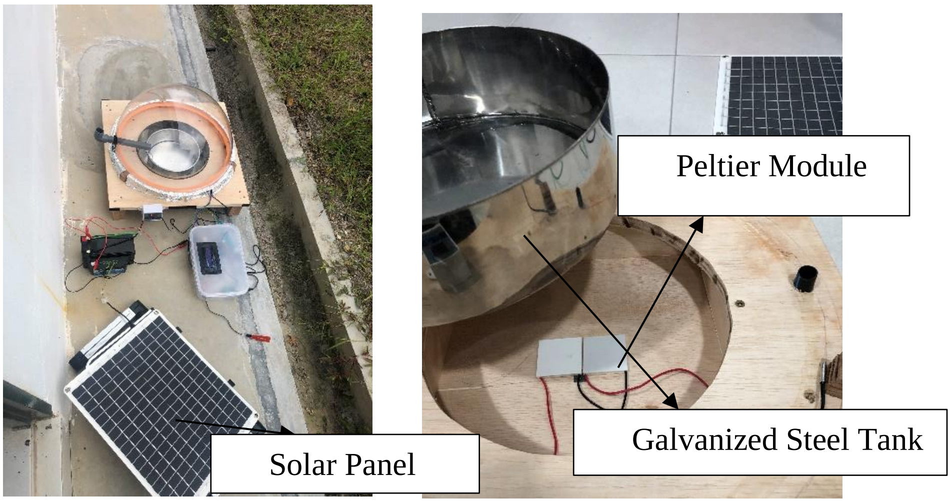

Figure 4.10 : Test 3 Setup HSSP

Figure 4.11 : Evaporation occurred in Test 3

Figure 4.12 : Temperature and Humidity in Solar Still

The water will be heated by the Peltier with the help of a 12V battery and solar panel. In order to control and optimize the charging process of batteries or other energy storage systems connected to solar panels, the battery connected to the solar controller and also referred to as a solar charge controller or solar regulator is used. By controlling the voltage and current supplied to the batteries, the solar controller maximizes the charging process. It guarantees that the right charging profile is applied to the batteries. Next, the temperature controller is connected to the output of the solar controller, which is connected to the solar panel A temperature controller's job is to control and regulate a system's or environment's temperature. Users can set the setpoint, or desired temperature value, with the temperature controller. In order to safeguard the environment or the system, temperature controllers frequently have safety measures. For the output at temperature controller connected to the Peltier for heating. Table 4.3 shows the result for test 3.

Table 4.3 : Test 3 Result

Time / Parameter	12:00 am	1:00pm	2:00pm	3:00pm	4:00pm	5.00pm	6.00pm
Temperature	44.8°C	45°C	44.5°C	44°C	44.2°C	44.5°C	45°C
Humidity	61%	63%	64%	65%	67%	69%	72%
Clean Water (ml)	None	None	10	25	50	60	72
Water Quality	9.00 pH	-	-	-	7.25pH	7.25pH	7.25pH

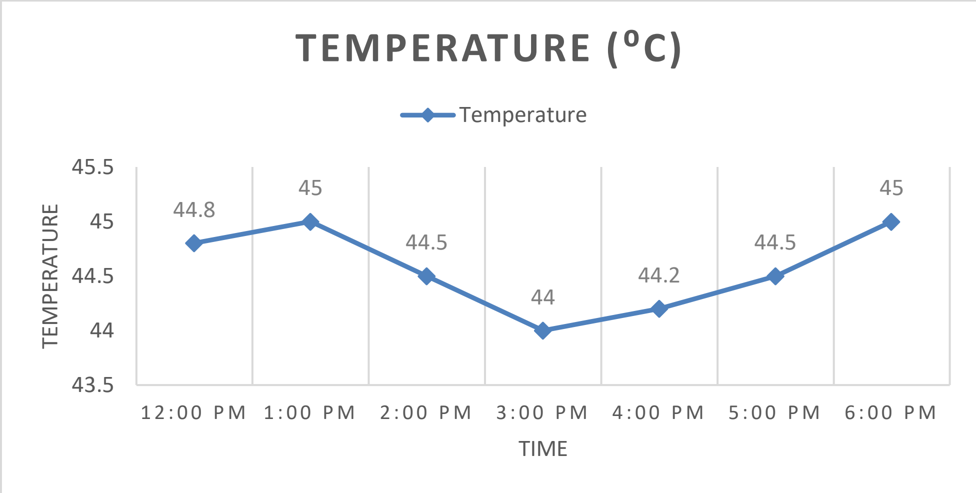

Figure 4.13 : Graph of Temperature in Solar Still for test 3

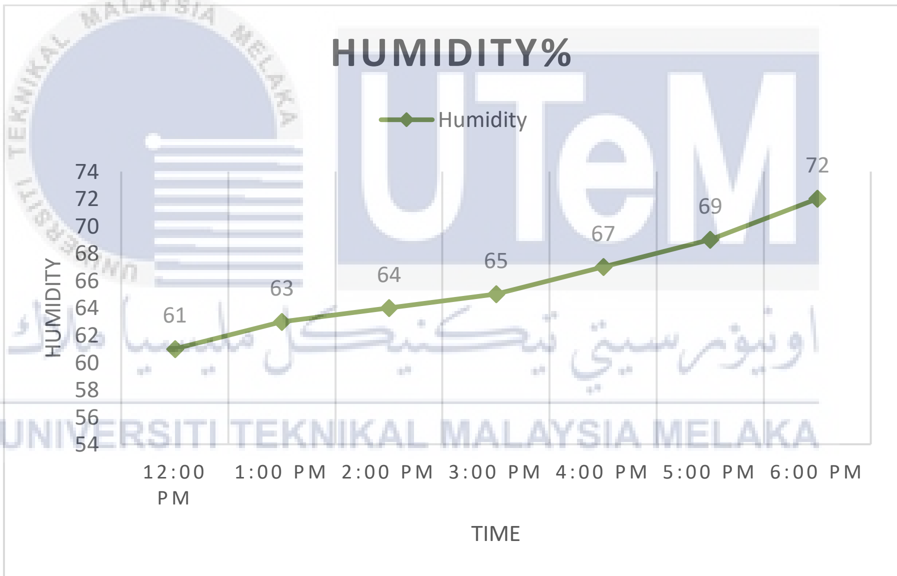

Figure 4.14 : Graph of Humidity In Solar Still for test 3

Figure 4.13 and figure 4.14 show the temperature and humidity graph for test 3. Analysis revealed that adding a Peltier device to the water reservoir significantly affects the humidity and temperature. The peltier and the temperature controller function as the moderator for the temperature to keep in 40 degree celcius and above. The start temperature for the peltier to be function is set at 40 degree celcius meanwhile the stop temperature is set at 45 degree celcius. This is to maintain the evaporation process ongoing throughout the test. The result of temperature and humidity can be compare with test 1 which is the test without using any heating element. The temperature in this test shows significant amount of increase comparing to the first test. This may result from the temperature and solar radiation during this test and the consistency of evaporation can be observed in this test due to addition of heating element which is peltier. The efficiency of the heating process in greatly accelerating the rate of evaporation is clearly visualized by the graphical representation of the acquired data. This acceleration is explained by the heating mechanism's facilitation of a significant rise in both the surrounding air temperature and humidity. Notably, around 72 milliliters of clean water are produced by this faster evaporation process. A closer look reveals that the resultant clean water has a pH of 7.25. It is crucial to remember that this pH value is within the permissible range of 6.5 to 7.5, which guarantees the safety and purity of the water. Consequently, these results show that the heating procedure used has no negative impact on the pH of the clean water that is generated.

4.1.4 Test 4 (Hemispherical Solar Still + Tap water + River Rock + Petier) (HSSRRP)

In the earlier test, it is found that the addition of river rock and the use of the Peltier effect during the heating process had a substantial impact on the evaporation process. Combining these two components is anticipated to result in a significant change in temperature and humidity, which then affect the efficacy and purity of the water generated. In order to guarantee a steady and dependable energy source, the Peltier element will be technically coupled to the battery and solar systems. In parallel, the river rock will be thoroughly combined with the water in the galvanized container to investigate the combined effects of the heating process and bagasse integration. Notably, significant changes in temperature and humidity dynamics are anticipated, which will ultimately affect the effectiveness and quality of the clean water that is produced. Around 200 gram of river rock is added into the aluminium tray inside the hemispherical solar still. Figure 4.14 shows the Tap water + River rock with Heater (Peltier) setup (HSSRRP).

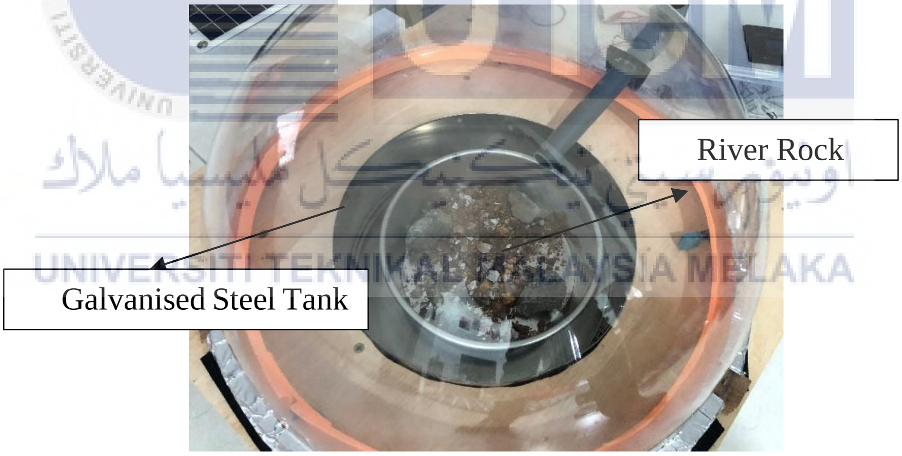

Figure 4.15 : Test 4 Setup (HSSRRP)

Table 4.4 : Test 4 Result

Time / Parameter	12:00am	1:00 pm	2:00pm	3:00pm	4:00pm	5.00pm	6.00pm
Temperature	38°C	40°C	43°C	45°C	47°C	50°C	52°C
Humidity	69%	69%	70%	71%	72%	75%	80%
Clean Water	None	10ml	30 ml	60 ml	78 ml	90 ml	108 ml
Water Quality	8.22 pH	-	-	-	7.25pH	7.24pH	7.25pH

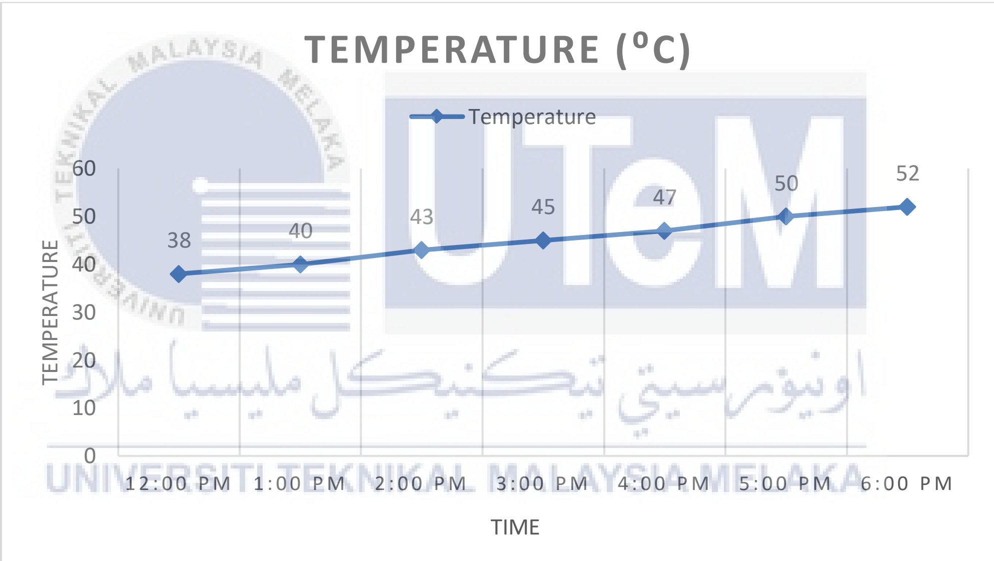

Figure 4.16 : Graph of Temperature In Solar Still For Test 4

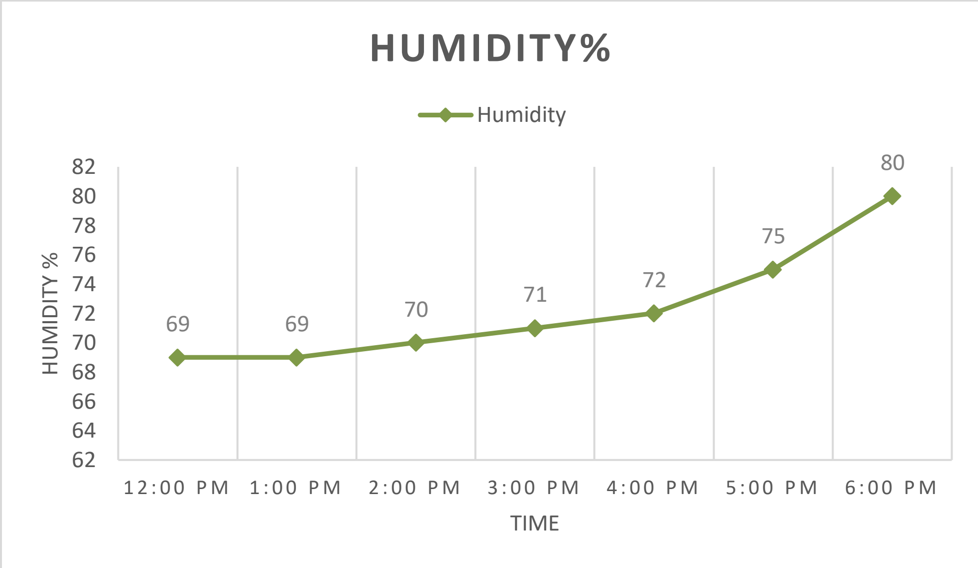

Figure 4.17 : Graph of Humidity In Solar Still For Test 4

Table 4.4 shows the result for test 4 and figure 4.16 and figure 4.17 shows the temperature and humidity graph for test 4. The employment of river rock and the Peltier effect in conjunction with the heating process has produced significant impacts on temperature and humidity, as indicated by the results of analysis test 4. It is important to note, that the temperature attained in this test is not as high as what was seen in test 3. This discrepancy can be explained by the fact that river rock was included in the experimental configuration, since it has been shown to have a moderating effect on the dynamics of temperature overall. On the other hand, in terms of humidity levels, this test has demonstrated the highest recorded values when compared to all other tests. This can be attributed to the synergistic interaction between the heating process and the river rock, wherein the heat absorption characteristic from the river rock promotes increased evaporation by facilitating enhanced contact between the water and the surrounding environment. This increased heat conductivity increases the temperature of the surrounding thus accelerated evaporation process. Consequently, the production of clean water in this test has exceeded that of test 3 which is 108 ml, suggesting enhanced effectiveness in terms of producing clean water at a faster rate. Despite the pH value of the clean water produced in this test measuring at 7.25 pH, it is crucial to note that the water remains within the range set by the World Health Organization (WHO) for clean and safe water, which spans from 6.5 to 7.5 pH. As a result, the water is still considered clean and suitable for various applications.

4.2 Summary

The analysis of the test results provided valuable insights into the impact of temperature, humidity, and various experimental factors on the water drop process and the production of clean and potable water. The evaporation process proved effective in significantly reducing the pH value from an initial reading of 8.22pH to 7.25pH, indicating enhanced cleanliness and safety of the water. The project's primary objective focused on optimizing the evaporation rate to achieve the fastest production of uncontaminated water, which was achieved by harnessing the power of solar radiation.

The inclusion of river rock in the experimental setup increased temperature levels and ongoing for a slightly more amount of time thus accelerated water vapor production, resulting in faster production of clean water. The utilization of a Peltier element in the water reservoir led to a notable increase in temperature and humidity levels, accelerating the evaporation process and yielding around 72 milliliters of clean water with a pH value of 7.25.

The combined use of the heating process and river rock further affected the temperature levels and evaporation rate, with river rock moderating the overall temperature dynamics. However, this combination resulted in the highest recorded humidity levels and enhanced production of clean water at a faster rate compared to other tests. Although the pH value of the clean water in this test measured 7.25, it still fell within the WHO's acceptable range, ensuring the water's cleanliness and suitability for various applications.

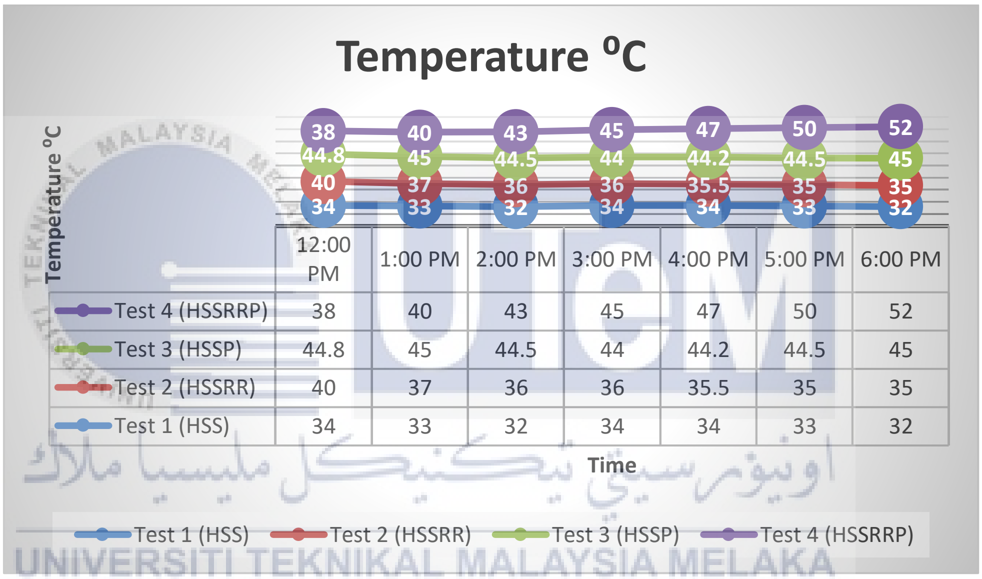

Figure 4.18 : Temperature In Solar Still for Test 1- Test 4

Based on figure 4.18 above which shows the combination of temperature from test 1 untill test 4 we can conclude that peltier and river rock has slightly effect in the increase in the temperature but cause the evaporation to sustain for a quite amount of time before the sun is set. But, there is also some effect from the solar radiation during that day that caused by the weather or the cloud is slightly visible at the sky during that day of test causing the temperature during the test is slightly higher from another test or day. Based on figure 4.19 below it also can be observed the realationship between humidity and temperature and figure 4.20 show the water level graph from the 4 test combined.

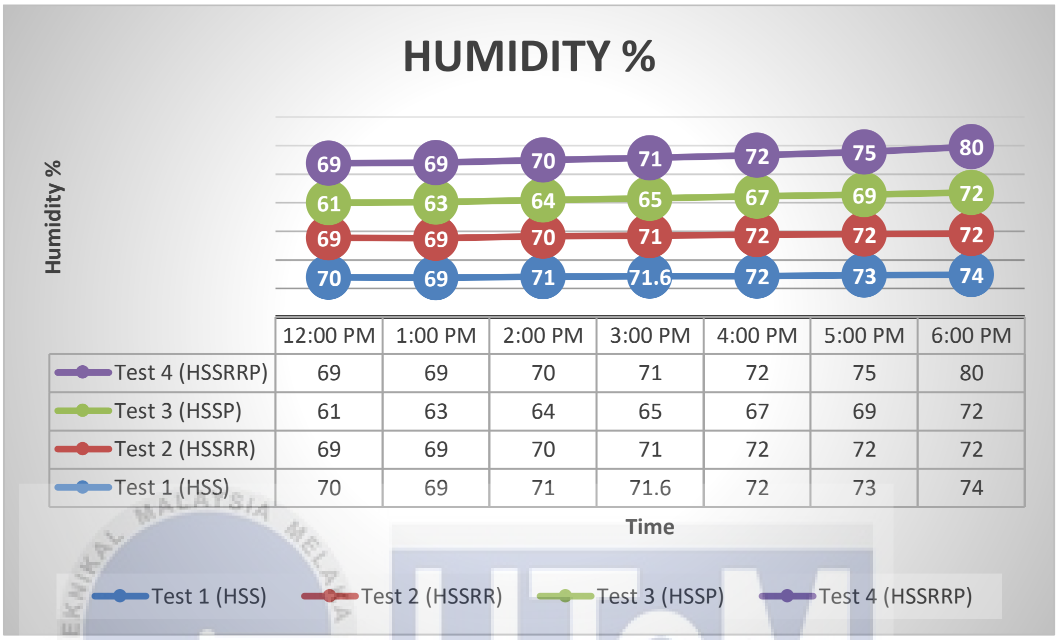

Figure 4.19 : Humidity Level In Solar Still For Test 1 – Test 4

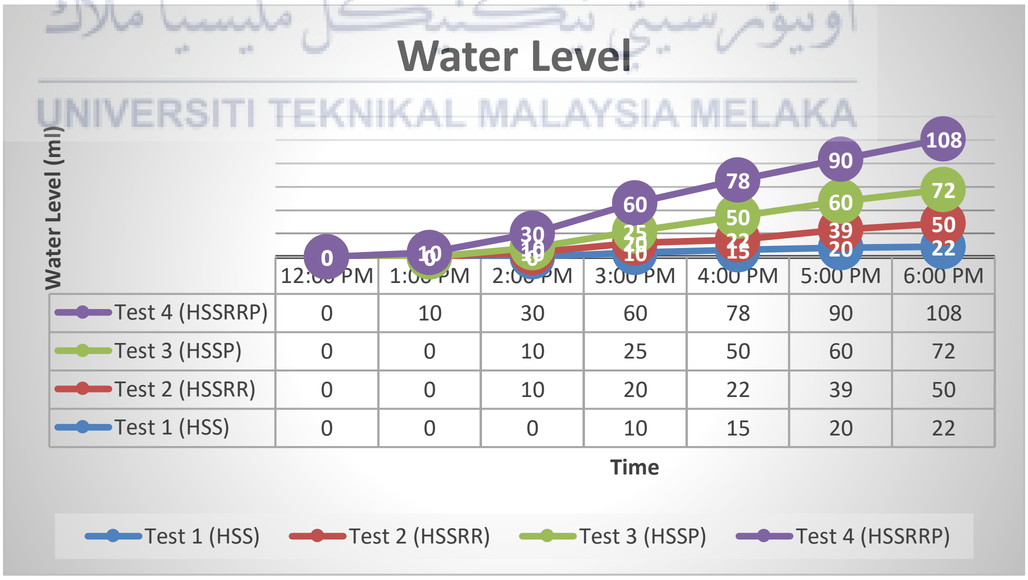

Figure 4.20 Water Level Of Collected Water During Test 1 – Test 4

From the figure 4.19 and figure 4.20, it can be concluded that the humidity level in the surrounding affect the evaporation process. From the figures, it also shows that the test has the highest efficiency of solar still as it produced the higest level of clean water which is 108 ml with pH level of 7.25. Figure 4.21 shows the pH value of clean water collected from test 1 until test 4.

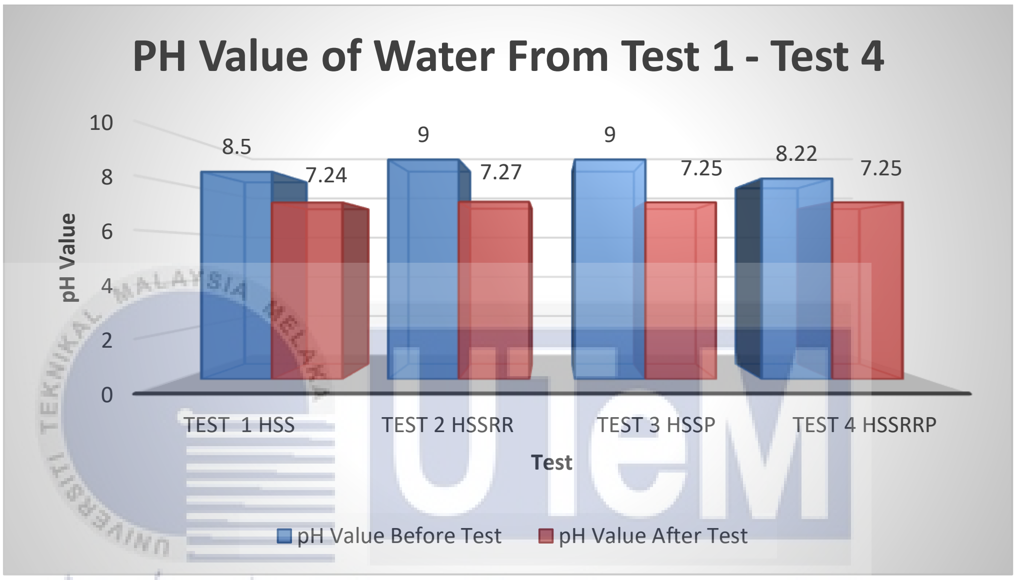

Figure 4.21 PH Level Result From Test 1 - Test 4

From the figure 4.21, it can be observe that the pH level from test 1 until test 4 do not show any significant differences between each other show that all the test able to produce the safe pH level of water. Last but not least, all the data above can be concluded that the humidity increasing by time and correlated to the rate of evaporation. By addition of river rock and peltier, the level of humidity also increases as the evaporation process occur after getting from those elements. Thus, the best practice for the enhancement of production of the clean water is coming from test 4 which is HSSRRP. But it also canot be deny that the main factor that increase and affect the level of temperature and humidity is the solar radiation. However, those heating elements can improve the overall performances of the hemispherical solar still.

Despite the excellence performance of this solar still, based on the conventional hemispherical solar still used in previous research it produce about 1.5L/m^2 [8]which is quite high compare to the finding of this version of hemispherical solar still. This can be due to the effect of bigger radius of hemispherical solar still and more completely covered design. For the previous research, the project also takes place indoor and by using artifical sun.. This may affect the higher production of the clean water.

Increment percentage of water level between test 4 to test 1 has been calculated and it is $\frac{108-22}{22} x\, 100 = 390\%$. Thus it shows that the test 4 has improved the evaporation process compare to the conventional hemispherical solar still.

CHAPTER 5

CONCLUSION AND FUTURE WORKS

5.1 Conclusion

In summary, the hemispherical solar still presents a practical solution for harnessing solar energy to generate fresh water, especially in remote and arid regions. Its distinctive hemispherical design maximizes the solar exposure area, facilitating efficient condensation and evaporation processes. This innovative solar still is not only effective but also simple to construct and operate, utilizing readily available and affordable materials such as acrylic or transparent plastic.

The hemispherical surface of the solar still enhances the collection of water vapor, allowing it to condense and trickle down towards the collection point. This design feature, combined with the use of a aluminium foil cover, helps to enhance the heat and solar radiation and accelerate the evaporation process. The evaporation and collection of purified water can be further improved through the inclusion of river rock. One of the notable advantages of the hemispherical solar still is its versatility and adaptability to varying environmental conditions. It can be adjusted to different angles to optimize water collection based on the latitude and prevailing sunlight angles. Additionally, the modular nature of the design allows for scalability, enabling the construction of larger arrays to meet increased water demand.

The hemispherical solar still offers an eco-friendly and sustainable solution for communities facing water scarcity. By harnessing the power of the sun, it reduces reliance on traditional energy sources and minimizes environmental impact. Moreover, its simplicity of operation and low maintenance requirements make it an accessible option for resource-constrained regions.

Last but not least, for this project it can be concluded that the experiment also affected by many factors such as the ambient temperature and the weather during test. It is quite a challenge to have a proper condition to make evaporation to occur throughout the test. But with addition of heating element such as peltier and river rock as the heating storage element may increase the efficiency of the conventional hemispherical solar still.

In conclusion, this project aims to design and evaluate the efficiency of a hemispherical solar still for purifying water using solar energy. By implementing the hemispherical method and integrating a thermoelectric system and the river rock effect, alongside real-time monitoring of water temperature and purity, the project overcomes limitations of conventional designs. The experimental setup includes a galvanized water container and a hemispherical acrylic cover, with sensors enabling continuous monitoring. By incorporating an Arduino Uno microcontroller, PH sensor, and water level sensor, real-time tracking of clean water volume and quality is achieved. Using a heating plate and river rock, the evaporation efficiency is enhanced by manipulating temperature and humidity within the hemispherical solar still. Experimental results show that, under daylight conditions and using specific methods, the final test which hemispherical solar still + peltier + river rock produces the most volume of water which is 108 m with a pH level ranging from 6.5 to 7.5. These findings demonstrate the potential of the hemispherical solar still design in improving efficiency and output quality, contributing to the alleviation of water scarcity and the promotion of sustainable water management worldwide.

5.1 Future Work

The future work in this area can focus on several key aspects to further enhance the performance and applicability of the Triangular Solar Still.

- ***Monitoring system:*** To keep up with the advance of the technology, this design can be improved by using a internet of things (IOT) realtime monitoring system. It is to be able to monitor the data from any platform that support the iot of the system. It is more easy to monitor rather than taking the data manually.
- ***Design optimization:*** Investigate various configurations of the hemispherical solar still, such as altering the angle and size of the panels, to ascertain the most effective arrangement. The best design parameters can be found by experimental testing and computational simulations.
- ***The effect of external factors***: Researching how the evaporation process is affected by outside variables like wind speed, humidity, and ambient temperature will help us comprehend the Triangular Solar Still's capabilities in a wider range of scenarios.
- ***Storage system integration:*** By including energy storage devices in the architecture, the Hemispherical Solar Still can function at night or in times of low solar radiation. Thermal energy storage and phase-change materials are two examples of efficient and reasonably priced storage technologies that could greatly enhance the still's overall performance and dependability.
- ***Neatness of power source :*** Future work can be improved by properly design the power source socket or insertion of power from the battery. For example a socket or a slot to insert the positive and negative wire from the component.

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APPENDICES

APPENDIX A

hemispherical_solar_still_finalize_2nd_version §

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <DHT.h>

#define DHTPIN 2
#define PH_SENSOR_PIN A0
#define WATER_LEVEL_PIN 3

DHT dht(DHTPIN, DHT11);
LiquidCrystal_I2C lcd(0x27, 16, 2); // I2C address 0x27, 16 columns and 2 rows

// Calibration values
int sensorValueOffset = 0-3;  // Offset to adjust the baseline reading
float pH4Voltage = 400;     //
float pH7Voltage = 700;     //

void setup() {
  Serial.begin(9600);
  lcd.begin(16, 2);
  lcd.backlight();
  dht.begin();
}

void loop() {
  float temperature = dht.readTemperature();
  float humidity = dht.readHumidity();
  int sensorValue = analogRead(PH_SENSOR_PIN);

  // Calibration adjustment
  sensorValue -= sensorValueOffset;

  // Map the sensor value to pH using calibration values
  float pHValue = map(sensorValue, pH4Voltage, pH7Voltage, 4.0, 7.0);

  int waterLevel = digitalRead(WATER_LEVEL_PIN);
```


hemispherical_solar_still_finalize_2nd_version §

```
  // Map the sensor value to pH using calibration values
  float pHValue = map(sensorValue, pH4Voltage, pH7Voltage, 4.0, 7.0);

  int waterLevel = digitalRead(WATER_LEVEL_PIN);

  lcd.clear();

  lcd.setCursor(0, 0);
  lcd.print("Temp: ");
  lcd.print(temperature);
  lcd.print(" C");

  lcd.setCursor(0, 1);
  lcd.print("Humidity: ");
  lcd.print(humidity);
  lcd.print(" %");

  delay(5000); //

  lcd.clear();

  lcd.setCursor(0, 0);
  lcd.print("pH: ");
  lcd.print(pHValue, 2);  // Display pH value with two decimal places

  lcd.setCursor(0, 1);
  lcd.print("Water Level: ");
  lcd.print(waterLevel == HIGH ? "High" : "Low");

  delay(5000); //
  // Add these lines in the loop() function for debugging
Serial.print("Raw Sensor Value: ");
Serial.println(sensorValue);

}
```

Figure 7.1 : Arduino Code For Monitoring System

APPENDIX B

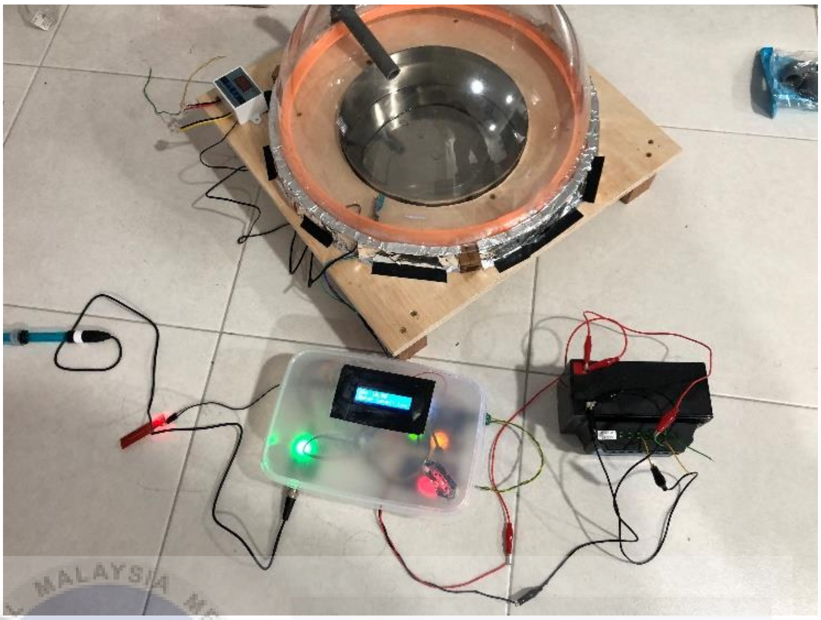

Figure 7.2 : Hemispherical Solar Still Final Look

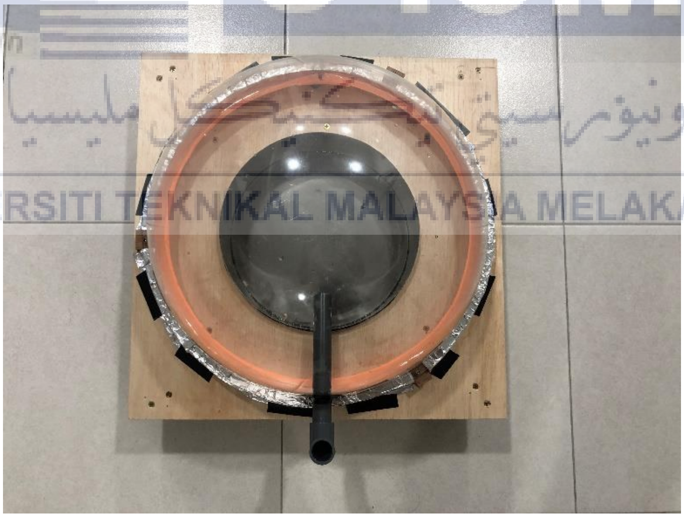

Figure 7.3 : Hemispherical Solar Still Top View

Figure 7.4 : Process of cutting wood for the base of the solar still

Figure 7.5 : Process of drilling a hole for the peltier cable insertion