ENHANCING THE PRODUCTIVITY OF TRIANGULAR SOLAR DISTILLERS USING INEXPENSIVE POROUS MATERIALS

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

Faculty of Electronic and Computer Technology and Engineering
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2024

DECLARATION

I declare that this report entitled “ENHANCE THE PRODUCTIVITY THE PRODUCTIVITY TRIANGULAR SOLAR DISTILLERS USING INEXPENSIVE POROUS MATERIALS” is the result of my own work except for quotes as cited in the references.

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Signature : ……………………………………

Author : MUHD NORMAN AL HAFIDZ BIN MOHD SOFI

Date : 21 JUNE 2024

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor of Electronic Engineering with Honours.

Signature : ....

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Supervisor Name : Ts DR AZDIANA BINTI MD YUSOP

Date : 21 JUNE 2024

DEDICATION

A special dedication and gratitude to Allah, the Almighty God, for my success in completing this project in time and for giving me the strength to overcome any trouble during this project. Also, to my parents Mohd Sofi Bin Abd Rahim and Suriyati Binti Hashim, my fellow friend for supporting me in terms of moral and physical to finish the project. Then, to my supervisor, Dr Azdiana Binti Md Yusop, for always guiding and sharing opinions to make this project successful.

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ABSTRACT

Solar distillation is an environmentally friendly method for obtaining fresh water through the utilization of solar energy. By using the sun's heat to evaporate and then condense water, this thermal application efficiently eliminates pollutants and impurities. This project focused on designing a Triangular Solar still that can increase water evaporation rates by using some agriculture waste which contains porous material. A few benefits of solar distillation are its sustainability, low maintenance needs and capacity to produce drinkable water from contaminated or saline sources. This project also focused on evaluating the design performance by monitoring and controlling all the factors that influence evaporation rates such as temperature, humidity, initial of water usage, solar irradiance, latent vaporization from solar energy and glass and wood materials of solar prototype. The combination of an Arduino Uno microcontroller, pH sensor, and water level sensor allowed for real-time tracking of clean water volume and quality. Experimental results show that, under daylight conditions and using specific methods, the triangular solar still produces almost 100ml of water with a pH level ranging from 5.48 to 6.8 using corn husks as a porous material. This method reduces the dependency on non-renewable energy and promotes the efficiency of natural resources.

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ABSTRAK

Penyulingan solar adalah kaedah yang mesra alam untuk mendapatkan air tawar melalui penggunaan tenaga solar. Dengan menggunakan haba matahari untuk menguwap dan kemudian mengkondensaasi air, aplikasi terma ini dengan cekap menghapuskan bahan pencemar dan kekotoran. Projek ini memberi tumpuan kepada mereka bentuk solar segi tiga yang boleh meningkatkan kadar penyejatan air dengan menggunakan beberapa sisa pertanian yang mengandungi bahan berliang. Beberapa manfaat penyulingan solar adalah kemampanannya, keperluan penyelenggaraan yang rendah dan keupayaan untuk menghasilkan air yang boleh diminum dari sumber yang tercemar atau garam. Projek ini juga memberi tumpuan kepada menilai prestasi reka bentuk dengan memantau dan mengawal semua faktor yang mempengaruhi kadar penyejatan seperti suhu, kelembapan, permulaan penggunaan air, sinaran suria, pengewapan laten dari tenaga solar dan bahan kaca dan kayu prototaip solar. Gabungan mikrokontroler Arduino UNO, sensor pH, dan sensor paras air dibenarkan untuk pengesanan masa nyata jumlah dan kualiti air bersih. Hasil eksperimen menunjukkan bahawa, di bawah keadaan siang dan menggunakan kaedah tertentu, solar segi tiga masih menghasilkan hampir 100ml air dengan paras pH antara 5.48 hingga 6.8 menggunakan sekam jagung sebagai bahan berliang. Kaedah ini mengurangkan kebergantungan terhadap tenaga yang tidak boleh diperbaharui dan menggalakkan kecekapan sumber semula jadi.

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First and foremost, I would like to thank Allah S.W.T, the Almighty, for His love and guidance. I have prepared this thesis to document all the details of my Final Year Project (FYP). I also want to convey my sincere gratitude to my supervisor, Dr. Azdiana Binti Md Yusop, for her advice, tolerance, understanding, inspiration, curiosity, and support throughout my research. Even though it has been a rough year, her guidance has really helped me finish this project. I am very thankful to have such a responsible and supportive supervisor during my final year at Universiti Teknikal Malaysia Melaka. I would also like to deeply thank my family, friends, and everyone else who has been engaged in my research. I am very thankful to my parents for their constant support and motivation throughout the achievement of this report. Their praise is greatly appreciated. Lastly, I want to thank all the lecturers for sharing their wisdom, providing advice, and giving additional teaching. This experience was very helpful and will be useful in the future. Thank you very much for everything, and I am grateful for all the contributions. Thank you.

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LIST OF SYMBOLS AND ABBREVIATIONS

For examples:

CSS	:	Conventional Solar Still
SGDs	:	Sustainable Goal Developments
°C	:	Celsius
DC	:	Direct Current
A	:	Ampere
W	:	Watt
V	:	Volt
WHO	:	World Health Organization
η	:	Efficiency of water evaporation rates
W_r	:	Water evaporation rates
L_v	:	Latent of heat vaporization
V_d	:	Volume of distilled water
E	:	Total energy absorb
t	:	Time period

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CHAPTER 1:

INTRODUCTION

This chapter analyzes all parts of the project that start with the problem to be solved and concludes with the desired outcome. The problem statement will explain how the project will address the issue in order to achieve the project's main goal. The primary aim is what is required to be accomplished for the project to be completed. The scope of work will indicate how the project will be performed as well as the desired outcome as stated in the purpose. The project methodology will demonstrate how the project operations procedure runs and will briefly describe the approach utilized to finish the project.

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1.1 Project Overview

It is well known that using solar energy is one strategy used by many developed and developing nations to protect the global environment. Certain facilities for industry and agricultural growth are powered by solar energy that is absorbed from the sun. The most significant renewable energy source for drying, solar cooking, water desalination, water heating, and air heating is the sun. Solar energy is also utilized in carbon-prevention devices, such solar stills that purify tainted water into fresh water.

The Solar Distilled Water Project aims to develop a device that converts unfit water into potable water by harnessing sun radiation. One may utilize the sun's energy to heat, evaporate, and filter water before condensing the vapor back into pure water by constructing a solar still. This approach is economical, safe for the environment, and particularly helpful in isolated locations without access to potable water. The solar still will be designed, constructed, tested, and evaluated as part of this project. Calculate and assess how much clean water is produced consequently. Reducing reliance on non-renewable energy sources and offering a sustainable alternative for access to clean water are the objectives. An additional method and apparatus to increase the performance of the solar still that is now in use is the application of thermoelectric cooling and heating.

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1.2 Project Objective

1. To design a Triangular Solar Still for water purification, considering factors such as porous material selection in agriculture waste.
2. To evaluate the efficiency of design performance in terms of water evaporation rates.
3. To analyze the quality of water purification.

1.3 Problem Statement

The Malaysian Ministry of Environment has released figures showing an encouraging trend in river water quality from 2008 to 2020. Water quality maintenance should be done often, nevertheless, as it is necessary for everyday usage. Numerous factors, including the discharge of industrial waste, flash floods, and unchecked human activity, can lead to contaminated water. Selecting the right agricultural waste materials, such corn husks, for the solar still is necessary to optimize water filtration. In order to optimize sun absorption and evaporation, the triangular form will be optimized within the design, all the while keeping the system economical and sustainable. This involves introducing agricultural waste into the solar still and monitoring the amount of water evaporation at certain intervals of time. This is crucial to maximizing the solar still's water purification effectiveness and ensuring that it is a workable solution for providing clean drinking water in areas with limited resources. Figure 1-1 shows the River Water Quality Trend from 2008-2020.

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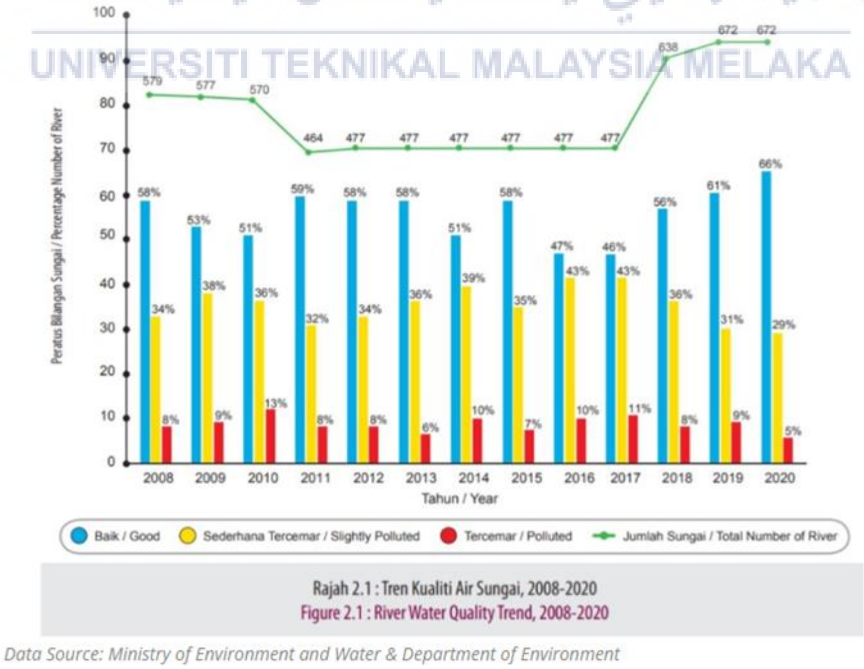

Figure 1.1: River Water Quality Trend from 2008-2020

1.4 Scope of Work

A more efficient solar still will be shaped with a black, light-absorbing surface and the perfect tilt to maximize solar exposure. The still will heat raw water in a reservoir using solar energy. A Peltier module, which generates a temperature differential when activated, will help with heating and cooling. The cold side will condense water vapor onto a glass surface next to a heatsink. An Arduino R3 will be used to monitor the pH and water level. A 20-watt solar panel coupled to 12 DC battery cells using a charge controller will power the system. To ensure efficient functioning, a W1209 temperature controller will be used to operate the Peltier module.

1.5 Methodology

Theoretically evaporation rates and condensation process are proportional to the surface area by solar still. The larger surface area produces a good performance into water vapor. Begin with gathering some glass plates to build up the triangle shape in order to get higher solar thermal. This shape has a wide evaporative area which makes it more productive by adjusting the cover angle and height.

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After design phase, construction work of the solar still where the selected materials are assembled according to the design specifications. Once the solar still completed, it moves to the testing phase. This step includes placing the solar still in an appropriate location with sunlight exposure and observing its performance over a period of time.

During the testing phase, a few parameters such as temperature and water collection are observed and recorded. The data collected from the testing phase is then analyzed to evaluate the efficiency and effectiveness of the solar still design.

Based on the analysis, some adjustments or improvements to the solar still design are made. This process is important to ensure that the project iteratively progresses towards an optimized solar still design.

Overall, the flowchart for the solar still project is necessary to see the systematic process from gathering materials to design, construction, testing, analysis, and documentation, enabling a structured approach towards achieving an efficient and functional solar still. Below if the view of flowchart in Figure 1-2.

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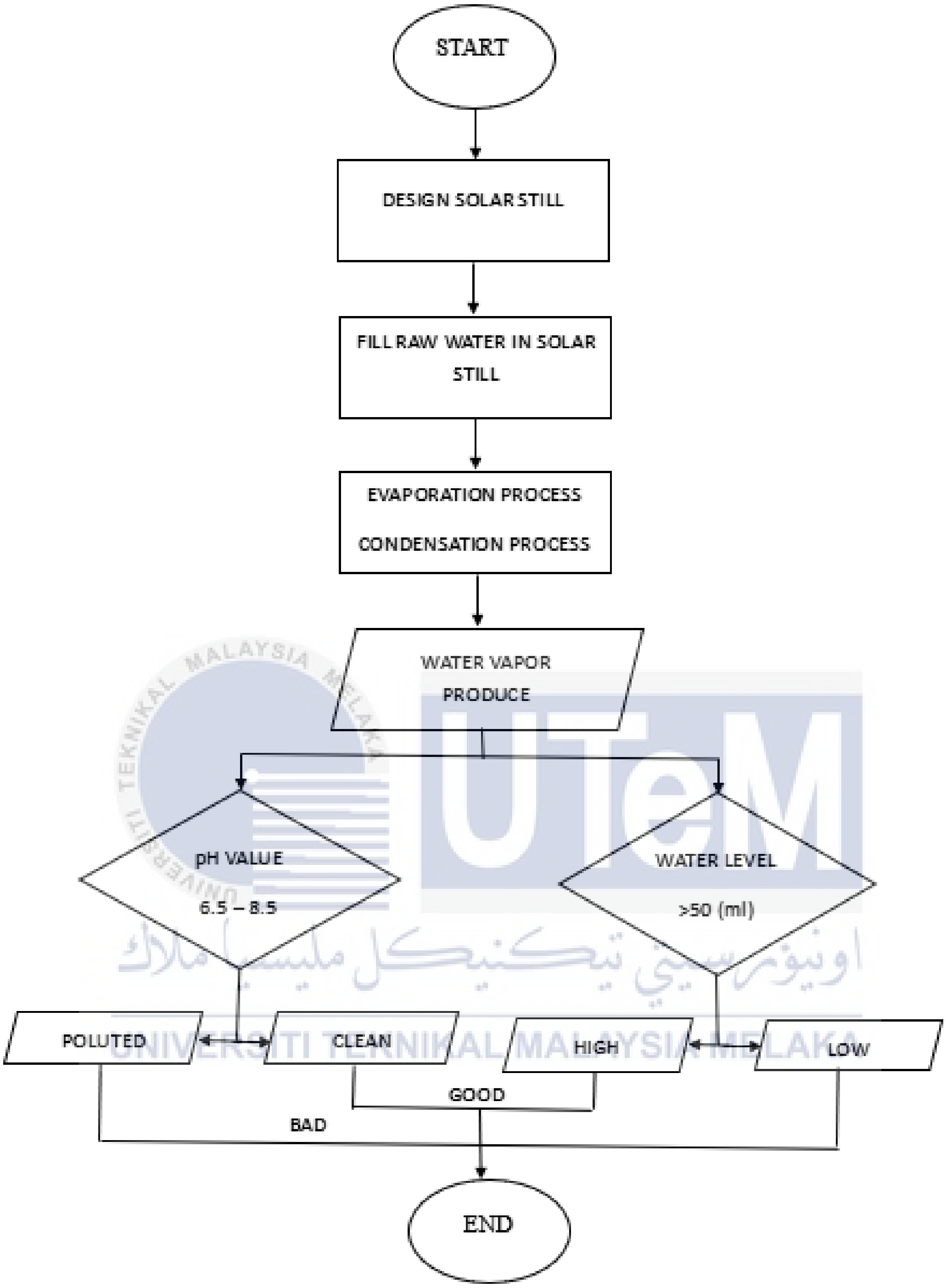

Figure 1.2: Flowchart for the whole project

1.6 Thesis Outline

The thesis content has 5 main chapters of studies. Chapter 1 is about Introduction of project and Chapter 2 is Background Study, Chapter 3 is Methodology, Chapter 4 is about Results and Discussion and the last chapter is Chapter 5 is Conclusion and Future Works.

Chapter 1 is the introduction to the thesis, and it contains the general understanding of the study, which addresses the project overview, objective, problem statement of the project, and the scope of work that the project will be covered.

Chapter 2 is about the background study, an important component of the project. It includes research into earlier works or periodicals that are relevant to and can help with the effort.

Chapter 3 is about the methodology, covers the flowchart, diagram, material and component used for the project as it will explain in greater depth why the selected part was used for the project and the technique and flowchart that will be utilized for finishing the project.

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Chapter 4 is about the result and discussion where every finding, error, and analysis of the project will be recorded and included in the chapter to know more about the project's flaws, strengths, and weaknesses. Every single finding of the project will be discussed in graphical data.

Chapter 5 is about the conclusion and future, where it solves the project's conclusion or final result, whether it is good or bad, if it accomplishes the project's goal, project ideas, and future work concerning the project.

CHAPTER 2:

BACKGROUND STUDY

This chapter will discuss data collection and theory related to the project's elements, the conventional solar still (CSS) and thermoelectricity theory and how it works. The theory of the component is essential since how effectively the materials perform will have a big impact on how the project works out.

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The review for the whole project is:

I. Climate Zone

II. Effect of Distillation and Evaporation

III. Conventional Solar Stills

2.1 Background study

The demand for drinking water is rising because of the world's population expanding more quickly than it has ever done. Fresh water is one of the few resources in the world that is essential to the development of nations and governments. Although water covers more than three quarters of the universe [1]. To develop a solar still that is more efficient, a lot of research has been conducted within the past 5 years. The most recent study conducted to increase distillate output using triangle solar stills is shown in the review paper that is currently available. Enhancing the air intake and outflow by the installation of a fan, flat plate collectors, evacuated tube collectors, and sawdust as a water absorber would increase the triangle solar still's capacity to produce distillate. A tabular comparison of various sun distillation system features and a list of components to improve the performance of a pyramid solar still are also presented.

2.2 Climate Zone

World data.info states that although Malaysia's weather is tropically humid, it is occasionally pleasant due to high temperatures and humidity. The average water temperature is 29 degrees, and the climate is pleasant to hot throughout the year. The country's wettest and hottest area is Kuala Lumpur. The coolest place is Kelantan. Because there is less rain in February, it is the best month to travel. Most precipitation falls from October to December [2]. Because evaporation requires less energy as temperature rises, higher temperatures result in shorter evaporation times. The quantity of water lost to evaporation in sunny, warm weather is more than in overcast, cool weather. Evaporation is influenced by humidity, which is commonly referred to as the amount of water vapor in the air. The air gets closer to saturation the more humid it is, and less evaporation may take place [3]. Figure 2-1 shows the pattern of average climate weather in Malaysia in year 2023. This data is taken from worlddata.info.

Region	Temperature max Ø day	Temperature min Ø night	Sunshine hours	Rainy days	Precipitation	Humidity
Johor	31.5 °C	24.8 °C	2,081 h	138	2,230 l	84.0 %
Kedah	31.9 °C	25.0 °C	2,446 h	149	2,259 l	83.0 %
Kelantan	31.2 °C	24.2 °C	2,519 h	138	2,668 l	84.0 %
Kuala Lumpur	32.9 °C	24.5 °C	2,227 h	172	2,993 l	83.0 %
Labuan	31.3 °C	25.0 °C	2,592 h	172	3,475 l	
Melaka	32.0 °C	24.2 °C	2,300 h	139	2,018 l	84.0 %
Negeri Sembilan	32.4 °C	24.5 °C		142	2,157 l	
Pahang	32.0 °C	23.7 °C	2,081 h	154	3,037 l	85.0 %
Penang	31.9 °C	25.0 °C	2,446 h	149	2,259 l	83.0 %
Perak	32.3 °C	24.0 °C		128	1,880 l	
Putrajaya	32.7 °C	24.5 °C	2,227 h	161	2,694 l	83.0 %
Sabah	31.6 °C	24.3 °C	2,482 h	160	2,924 l	82.0 %
Sarawak	31.8 °C	23.7 °C	2,081 h	193	3,697 l	86.0 %
Selangor	32.7 °C	24.5 °C	2,227 h	161	2,694 l	83.0 %

Figure 2.1: Climate weather in Malaysia

From 1960 to February 2023, the Kuala Lumpur Airport weather station recorded the highest temperature. This location had a record high temperature of 39.0 °C in October 2019. Based on data from all 16 weather stations in Malaysia, the warmest meteorological summer from December to February was seen in 1998, with an average temperature of 28.0 °C. Normally, this average temperature is taken every four to six hours, which includes the evenings. This number is typically 26.9 degrees Celsius. The Kota Bharu weather station recorded the coldest day in these sixty-four years. In February 1999, the temperature fell to 12.8 °C here. Five meters are Kota Bharu's elevation above sea level. With an average temperature of 25.9 °C from June to August 1971 was the coldest winter on record. It typically becomes around 1.4 degrees Celsius higher in Malaysia over this three-month period, reaching 27.3 °C. The most precipitation fell in December 2014. At 58.7 mm per day, the Kuantan weather station recorded the highest monthly average of the last 64 years. Incidentally, the region with the most rainfall for the whole year is around Kuching. The driest region is near

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Sitiawan. In the years after 1992, the average annual temperature was around 27.0 °C, and in the final years before 2023, it was roughly 27.5 °C. Thus, throughout the previous 32 years, it has only marginally increased—by around 0.5 °C. This pattern is exclusive to the 11 weather stations in Malaysia that have been chosen. A different assessment of global warming that is far more thorough has been supplied. Figure 2-2 shows the average annual temperature in Malaysia from 1992 until 2023.

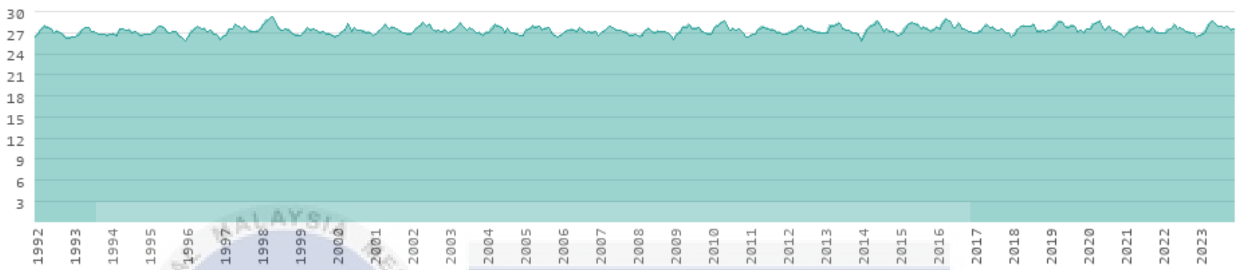

Figure 2.2: Average annual temperature in Malaysia

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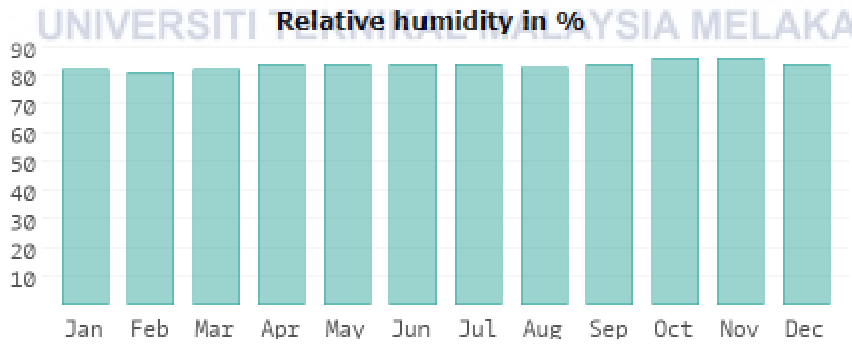

Figure 2.3: Relative humidity in %

According to the graph in Figure 2-3, the humidity and the weather is stable throughout the year, which is beneficial to this project because humidity is one of the factors. The year-round consistency of weather and humidity levels is very helpful to this project since it guarantees the reliable operating conditions of solar stills. Consistently high humidity levels offer a steady supply of moisture, which facilitates the condensation process and produces a consistent amount of distilled water. Consistent solar radiation and ambient temperature, along with predictable weather patterns, enable the design and operation of solar stills to be optimized for maximum evaporation rates with minimal need for frequent modifications. Additionally, because of its predictability, there is less chance of disruptions from extreme weather events like storms or heavy rainfall, and there are less variations in air pressure that might influence the production of water.

2.3 Desalination water

A system called a solar still utilizes solar radiation to remove salt and other impurities from contaminated water. a method of purifying water for use in various home and commercial settings that uses solar radiation to separate polluted water from drinkable water. It is simple to understand how solar energy is used to create fresh water from brackish, salted, or polluted water. There are numerous solar still designs that increase the productivity of freshwater evolved over the past thirty years [4]. Water evaporates into the air when left in an open container in an open place. The rate of evaporation is affected by factors such as temperature, humidity, and wind speed [5]. Theoretically, solar-generated water ought to be pure. During the slow distillation process, only pure water evaporates from the pan and gathers on the lid, leaving all particle contaminants behind. Condensation is the process through which a gas changes from gas to liquid. It takes place when the forces holding molecules in a gas apart are overcome by their own energy loss, allowing the molecules to merge and form a liquid. This process is driven by the difference in vapor pressure between the gas and the liquid. Condensation can occur accidentally, as in the case of a distillation

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operation, or deliberately, as in the case of water vapor in the air cooling and turning into dew or frost. The rate of condensation is affected by factors such as temperature, pressure, and the presence of condensation nuclei [5]. Figure 2-4 shows the distillation process.

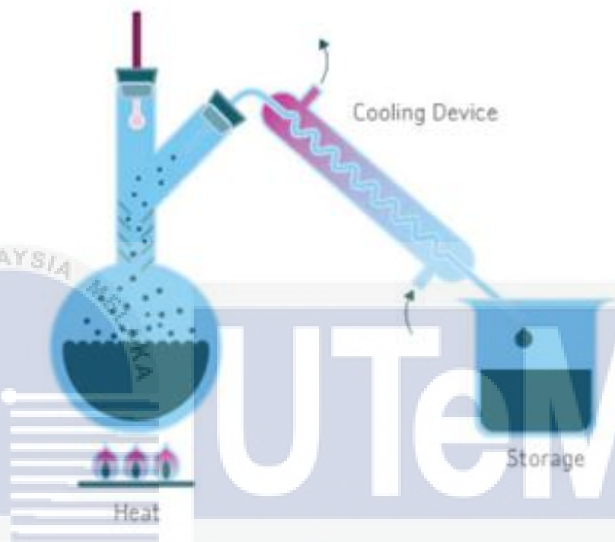

Figure 2.4: Process of distillation.

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2.4 Type of Solar Still

Single effect and multi-effect solar stills are the two forms of solar stills that may be distinguished. Depending on the heat source that is used to evaporate the water, each of these stills is further divided into active and passive categories.

2.4.1 Active Solar still

Clean water is produced in an active solar still by using extra thermal energy from the solar collector. For faster evaporation, this kind of additional thermal energy is combined with passive solar energy. It can be obtained via a solar collector, or any excess thermal energy produced by thermal equipment like thermoelectric heaters.

The Seebeck Effect, the Peltier Effect, and the Thomson Effect are two of the three effects of the thermoelectric effect [4]. Using a thermoelectric module, one may convert various temperatures into electric voltage or vice versa using the thermoelectric effect. Combining two other alloy metals with different electron densities results in the thermoelectric effect. Figure 2-5 shows the thermoelectric effect sequence.

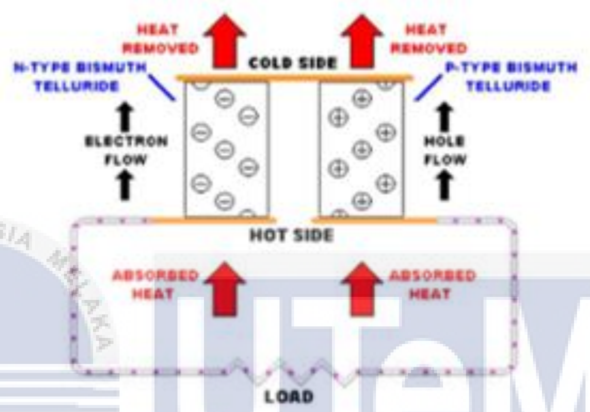

Figure 2.5: Thermoelectric effect sequence.

2.4.2 Passive Solar Still

In this method, the polluted water in a basin is heated by sun radiation, which causes the water to evaporate. Passive solar stills operate at low temperatures, usually just above room temperature, which facilitates effective evaporation without requiring a significant amount of energy. It takes just this small amount of energy for water molecules to change from a liquid to a vapor. Rapid development of distilled water is mostly due to the low vapor pressure within the still. The pressure that a vapor exerts when it is in equilibrium with its liquid or solid state is known as vapor pressure. Because of the comparatively low vapor pressure at lower operating temperatures, water vapor evaporates more slowly yet steadily, limiting major water vapor loss and guaranteeing efficient condensing on the colder surface of the still's cover. The

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evaporated water is collected by this condensation process as clean, drinking water. Heat is exchanged when two things of different temperatures come into contact until they are at thermal equilibrium [7]. The direct transmission of heat energy between two items by molecular contact is known as conduction. Figure 2-6 shows the Solar Thermal Radiation concept.

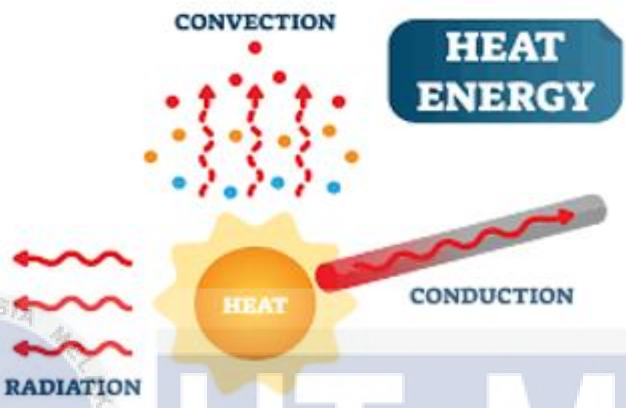

Figure 2.6: Solar Thermal Radiation

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2.5 Various Design and Configuration Solar Still

The advantages of employing various active techniques and increasing the number of steps to enhance the rate of evaporation and condensation when compared to a basic conventional type solar still. This evaporated (or distilled) water is captured by condensing it onto a cold surface, which is the function of the solar still [8]. The advantages of solar stills include simplicity, reliable systems, inexpensive, ease of maintenance, low operation effort, and low environmental impact, while the most significant disadvantage is the low efficiency and productivity due to the large loss of heat to environment and the need for a large amount of thermal energy to heat the basin water [9]. Figure 2-7 shows the various solar still configurations.

Figure 2.7: Various solar still configurations design

Solar stills are often the easiest to construct, consisting of a container half filled with salt water and capped with a glass cover. Solar still provides a higher surface area for the condensation process than basin solar and produces good performance [10]. Solar stills generally work through the distillation process. The solar distiller of other types needs to be placed in such a way that its inclined surface is facing direct solar radiation, and it also needs to be moved continuously as the sun travels throughout the day to capture the maximum amount of energy throughout the day [11]. Solar radiation is absorbed by the water in the still's basin and utilized to evaporate the salty water. Natural convection pulls the produced vapor towards the upper transparent cover, where it condenses on the transparent cover's colder inner surface. As water vapor condenses on the top, it descends the sides and is collected and released by gutters. The primary drawbacks of the conventional solar still (CSS) are its large surface area need and low distillate production. Figure 2-8 shows a few of solar still’s design.

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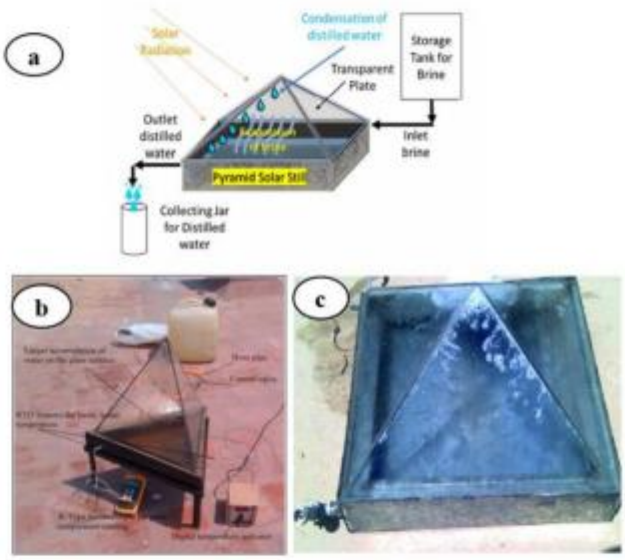

Figure 2.8: a) conventional pyramid solar still b) triangular pyramid solar still c) square pyramid solar still.

The conventional pyramid solar still, the triangular pyramid solar still, and the square pyramid solar still are three variations in the field of solar still designs, each with its own special qualities. Typically, a traditional pyramid solar still has a wide base and a single, sloping cover that ends at a point to maximize surface area for water collection and sun absorption. The triangle pyramid solar still emphasizes a more compact form that can be simpler to build and maintain while still producing water effectively. It is typically built with three triangular sides and a flat base. However, the square pyramid solar still, which has a square base and four triangular sides, combines a robust construction with a larger surface area for condensation and evaporation, perhaps increasing total efficiency. Every design seeks to maximize the utilization of solar energy to provide clean water, but there are differences in the designs' stability, efficiency, and complexity of construction.

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2.6 Inclination of solar still glass

In their study, Kabeel et al. (2016) [12] conducted an experiment with a three-square pyramid solar still that has a top cover that is inclined at various angles. Triangular solar stills should typically be inclined at an inclination between 0 and 30 ° for the best possibility of capturing the most sunlight throughout the day. The reason for this is that improved sunlight absorption is made possible by a lower inclination angle and because the sun's path is above equatorial latitudes. Figure 2-9 shows the comparison of inclination of glass to impact the performance.

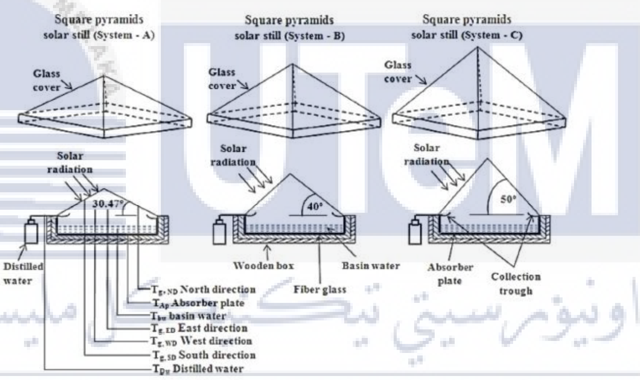

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Figure 2.9: Inclination of Pyramid solar still design

The efficiency and efficiency of a pyramid solar still design in producing water is greatly dependent on its slope. The way the transparent cover slopes determine several important parameters. The rate of evaporation may be accelerated by increasing the heat transmission to the water's surface by a steeper inclination angle, which can improve solar radiation absorption. This is especially helpful in areas with less sun energy or in the winter months. On the other hand, by encouraging greater water droplet runoff towards the collecting site, a shallower inclination angle may maximize the condensation process. The angle affects the solar still's resistance to wind and other external conditions as well as its structural stability. To optimize daily sun exposure, the inclination angle must also consider seasonal fluctuations in solar height and geographic location. Therefore, to achieve the best water production efficiency and guarantee dependable operation under a variety of climatic situations, the inclination angle in pyramid solar still designs must be carefully chosen.

2.7 Humidity and Temperature Factors

The amount of water vapor in the air is directly correlated with temperature and humidity. The gaseous form of water, known as water vapor, may be found in the atmosphere in the form of water droplets or vapor. As the temperature rises, air's capacity to hold water vapor increases. Because gas particles travel more quickly and are more prone to escape into the air when a gas's temperature rises, this is done to increase the amount of water vapor present. Conversely, humidity quantifies the amount of water vapor present in the atmosphere. There is a set amount of water vapor in the air at 100% relative humidity. Humans can't change the amount of humidity in the air because it's a weather factor [13]. The connection between relative humidity and temperature is inverse, meaning that relative humidity decreases as air temperature rises and increases as air temperature falls. This is because the air's capacity to retain water vapor is reduced and relative humidity is higher at lower temperatures. A lower relative humidity is indicated if the air is not completely saturated [13]. The ability of the air to store water vapor increases with temperature, but the relative humidity decreases [14]. While relative humidity falls as temperature rises, the air's ability to hold water vapor grows as well. Figure 2-10 shows the relative humidity with water vapor against the temperature graph.

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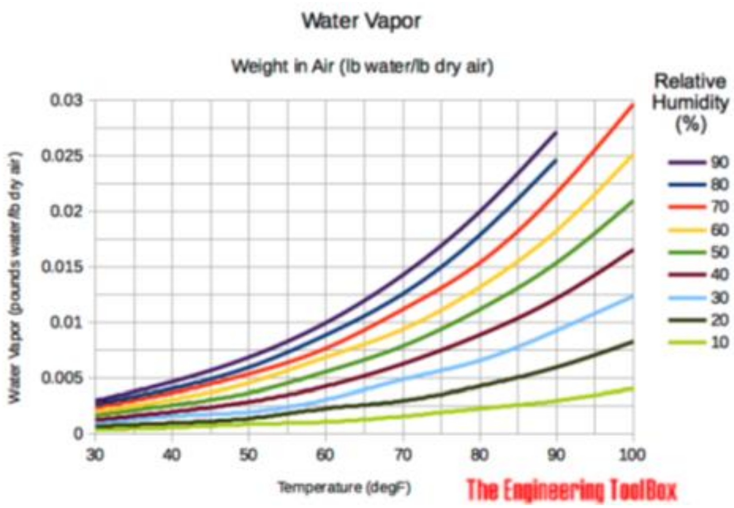

Figure 2.10: Relative humidity

2.8 Parameters Solar Still Identification

The amount of water a basin area produces in a day is a common indicator of solar still performance. Three variables affect the volume of water produced by solar stills: operational, design, and meteorological or climatic. Water coloring, water flow, surfactant additions, salinity and pollutant levels, system upkeep, water feeding, solar still location, and a few other impacts are among the operating parameters. The sun radiation, outside or ambient temperature, relative humidity, wind speed, dust, and cloud cover are among the meteorological parameters. The design factors also include the number of slopes and basins, the types of still designs, and the slope's inclination. Many uncontrolled factors, such as temperature, humidity, wind direction, cloud and dust cover, and solar radiation intensity, influence performance. Design and operational features may be easily changed to boost efficiency even when the environment in which solar electricity is used cannot be regulated. Figure 2-11 shows the Parameters affecting solar still productivity [14].

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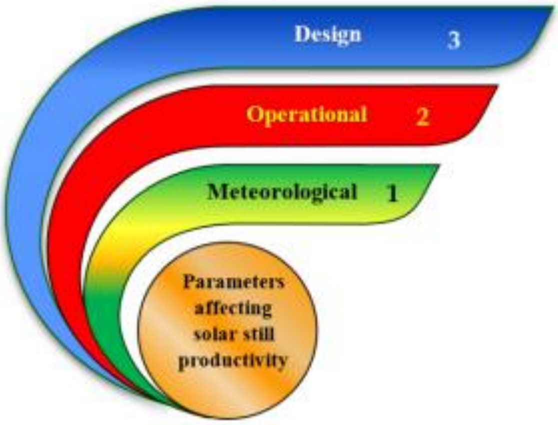

Figure 2.11: Parameters affecting solar still productivity

The amount of water that a basin area produces each day is a popular way to gauge the efficiency of solar stills using climatic criteria. Outputs are strongly related to their input, which is solar energy in this situation [15]. Figure 2-12 shows the characteristics of meteorological parameters.

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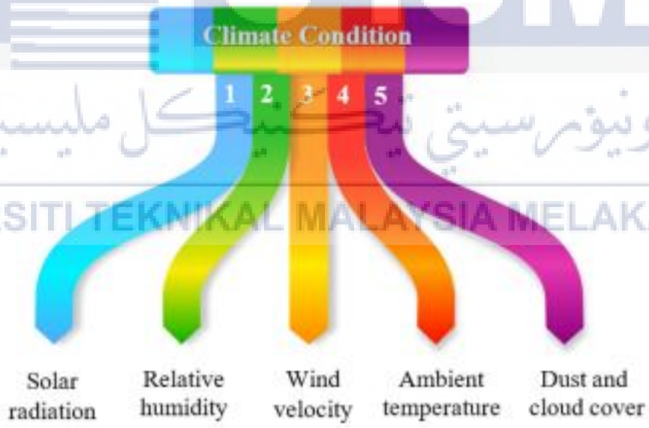

Figure 2.12: Meteorological parameters characteristic

Solar output is directly impacted by operational factors. Solar performance can still be raised by improving the design and tunable operational elements. The following picture displays several operational factors. These parameters include things like the color, flow, surfactant additives, salinity and pollutant levels, water supply for system maintenance, placement of the solar still, and other things. There is a quantifiable relationship between still production and water salinity. It is usually noted that when salinity increases, distilled water output decreases [15]. However, the placement of the solar still and the water feeding technique are the two most important factors. Figure 2-13 shows the classification of operational parameters.

Figure 2.13: Operational parameters classification

The active and passive solar stills' design characteristics mostly determine how well the still performs. Many academics worldwide appropriately consider a wide range of design parameters, including the quantity of basins and slopes, the different forms of still designs, the cover's inclination, thermal energy storage, basin absorption rates, reflectors and mirrors, sun tracking systems, insulation thickness, additive materials, and the basin's water depth. Stills with a single slope and a south facing covering are utilized for north latitude locations, whereas those with a single slope and a north-facing covering are used for south latitudes locations [16]. Figure 2-14 shows the configuration of design parameters.

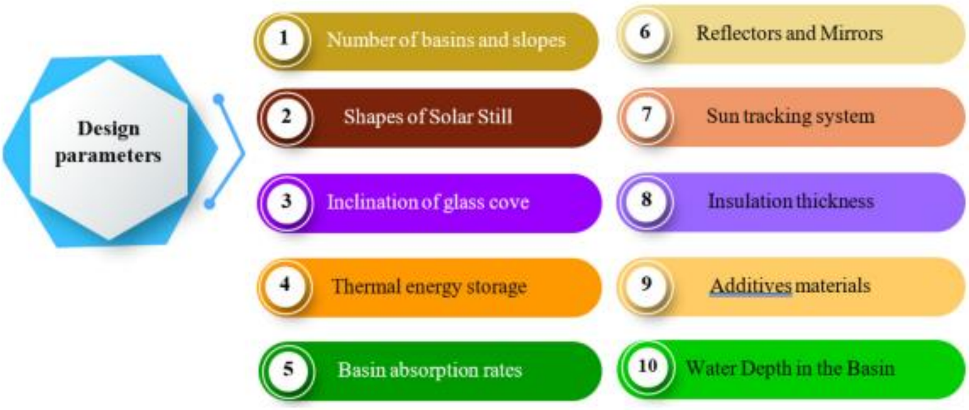

Figure 2.14: Design parameters configuration

2.9 Quality of Water

There is no official pH guideline for water established by the World Health Organization (WHO). However, the WHO does provide guidelines for pH values related to the quality of drinking water. This range is considered acceptable for most people and does not pose any significant health risks [16]. The WHO Guidelines for Drinking-water Quality state that the normal pH range for drinking water is between 6.5 and 8.5. It's crucial to remember that the WHO criteria encompass a wide range of factors, including chemical composition, physical attributes, and microbiological pollutants, in addition to pH, which is only one component of water quality. Figure 2-15 shows the universal pH scale by referring to the quality of water.

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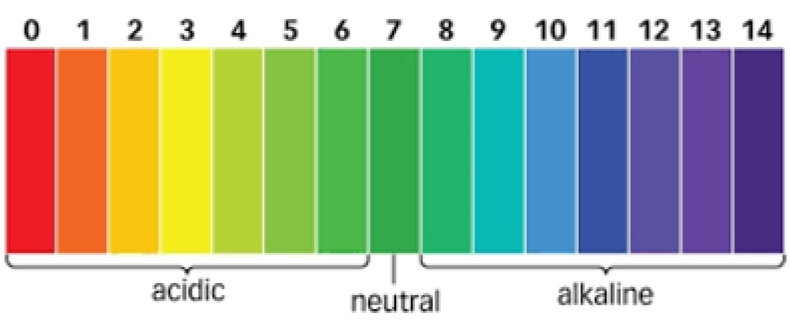

Figure 2.15: pH scale for water

2.10 Porous Materials in Desalination water

By enhancing water absorption, retention, and evaporation rates, porous materials in solar stills greatly improve water purifying efficiency. Because of their large surface area, which promotes increased water dispersion and solar contact and speeds up the evaporation process, these materials are especially effective. By increasing the saline water temperature, the water vapor increases inside the solar still cover and distilled freshwater formed after collision with the inner surface of the glass [17]. Due to their high lignin concentration, corn husks are recognized for their durability and resistance to microbiological degradation, which guarantees long-term efficacy. Improved heat distribution within the still is made possible by these materials increased thermal conductivity, which is essential for reliable and effective water evaporation. These porous materials improve the overall quality of the water by helping to pre-filter contaminants. The amount and quality of distilled water have significantly improved when these materials are included into solar still designs. Utilizing agricultural waste promotes the use of renewable resources and lessens environmental effect, which is in line with sustainability goals. The depiction for porous materials is presented in Figure 2-16.

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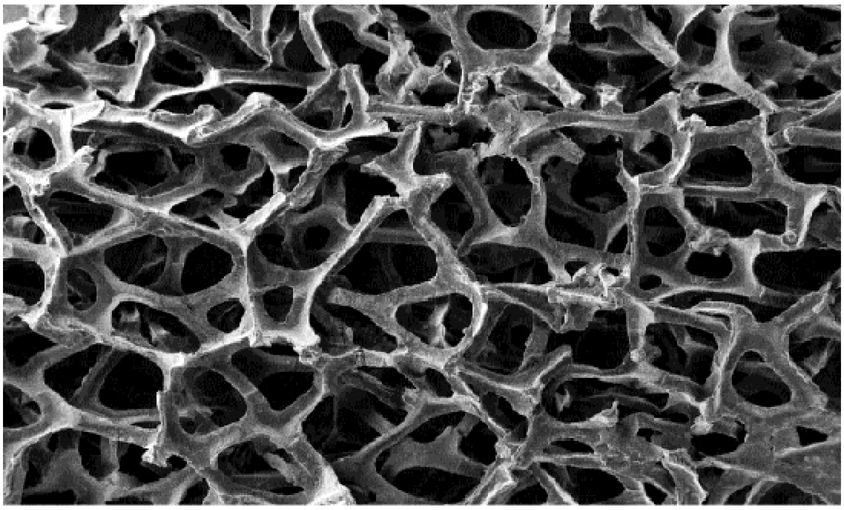

Figure 2.16: Porous materials

2.11 Summary Background Study

The triangle solar still design, inclination, relative humidity, relative temperature, water purification, and productivity of distilled water are all related to each other. The solar still's performance and efficiency are influenced by its slant and design, which maximizes sunlight absorption for improved evaporation. Higher relative humidity levels inhibit evaporation, whereas lower relative humidity levels encourage quicker evaporation and condensation. Higher temperatures speed up evaporation, hence the relative temperature is important. The main objective is to purify the water, which is accomplished by separating the contaminants during evaporation. Design, inclination, relative humidity, and relative temperature all affect distilled water production; optimizing these variables will increase the amount of filtered water produced. In general, the triangle solar still design, inclination, relative humidity, relative temperature, water purification, and productivity of distilled water all work together to optimize the utilization of solar energy for effective water purification.

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CHAPTER 3:

METHODOLOGY

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The approaches utilized to complete the project are detailed in-depth in this chapter. It explains how the project was carried out to achieve the project's goals. This chapter also includes a discussion of the project process and the stage-by-stage building of the prototype. In addition, the functionality and working principle of each component utilized to make the prototype are thoroughly discussed. This chapter also goes over the steps for implementing each item in a prototype.

3.1 Project development process

The two parts of this project are a monitoring system and a heating module. The solar still's trapped vapor water will increase. the transformation of condensation into water that is collected in a separate container. The heating plate heats the combination of water and porous material. To heat water, the heating plate functions as a water heater. The goal is to quicken the pace at which water vapor turns into gas. The efficiency of the thermoelectric cooling and heating system will be assessed by analyzing all the observed data.

The project warmed the water and increased the volume of water that evaporates every day by using thermoelectric heat in conjunction with solar energy. The water level sensor and pH value water vapor will be controlled by an Arduino Uno Rev2, while the thermoelectric heating plate will be powered by a 12V DC battery. The efficient temperature environment will also be managed with the aid of a W1209 digital temperature controller, and the outcomes will be shown on an LCD 20x4.

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The weather and temperature have an impact on the project in order to affect how well a solar still performs. The boiling point of a temperature is reached at higher humidity levels. The amount of moisture in the air encourages efficient condensation, which gathers clean water. In the meanwhile, higher temperatures that are powered by solar thermal energy can accelerate the pace of evaporation. Finding a balance is essential, though, since low humidity and high temperatures can impede the evaporation process, while too high temperatures might confuse condensation. To maximize water output in a solar still, humidity and temperature optimization are crucial. Understanding design factors and parameter adjustments is required to maximize solar energy harvesting while taking current humidity levels into account.

The idea of a thermoelectric system helps this project to improve the solar still's efficiency. In theory, the system enables temperature management, which can maximize enhanced condensation rates and evaporation rates. In poor weather and situations with little solar radiation, the Peltier module functions as a thermoelectric heating element. To ascertain if the thermoelectric idea will be successful in creating a solar still, several criteria like cost, size, materials utilized, and complexity must be considered.

Temperature, water level salinity, and clean water quality are a few of the project's factors that must be measured and examined. These variables improve the production of clean water and enhance the heating process. This is a significant component of the unfavorable weather patterns that prevailed during the testing period. It might affect the overall operation of the system and the generated data to consider external elements like weather. A complete study that assesses the system's efficacy and efficiency may be carried out by looking closely at and comprehending its mutuality

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3.2 Circuit configuration

Solar panels are used to absorb solar energy, which is then stored in battery cells for later use. A solar charge controller is used to manage the charging process. To further harness temperature differentials for power generation, Peltier thermoelectric modules are included. By integrating the processes of solar energy capture, storage, and temperature gradient utilization using Peltier technology, the entire system guarantees a dependable and sustainable power supply. The integrated system consists of an Arduino Uno acting as the central controller, a solar charge controller that controls solar energy to charge a battery, and several sensors, such as pH, temperature, and water level sensors. When the testing procedure started, a temperature controller was utilized to regulate the battery cell's thermoelectric output power supply. The Arduino analyses information from sensors, decides what to do depending on preset criteria, and manages other hardware like dosing systems or pumps. Real-time monitoring and control of water-related factors for use in environmental management, aquaculture, and agriculture are made possible by this extensive system. Figure 3-1 shows the block diagram of the whole project.

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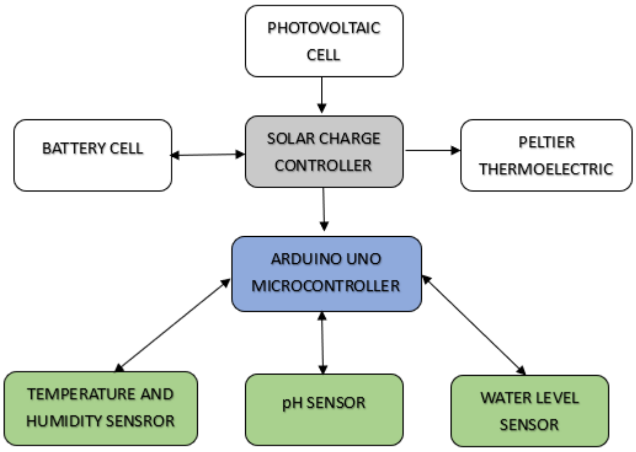

Figure 3.1: Circuit Methodology

3.3 Power Supply Design

The solar controller is selected to manage the voltage and current flowing from the solar panel to the battery to power up the electronic controller. It makes sure the battery is neither overcharged nor discharged, which can shorten its lifespan and cause harm to the battery. The solar controller serves as a connection between the solar panel and the battery in a 12V DC battery system. To prevent overcharging or over discharge of the battery, it controls the voltage and current coming from the solar panel to the battery. Additionally, at night, the controller keeps the battery from draining back into the solar panel. Figure 3-2 shows the circuit diagram for power supply design.

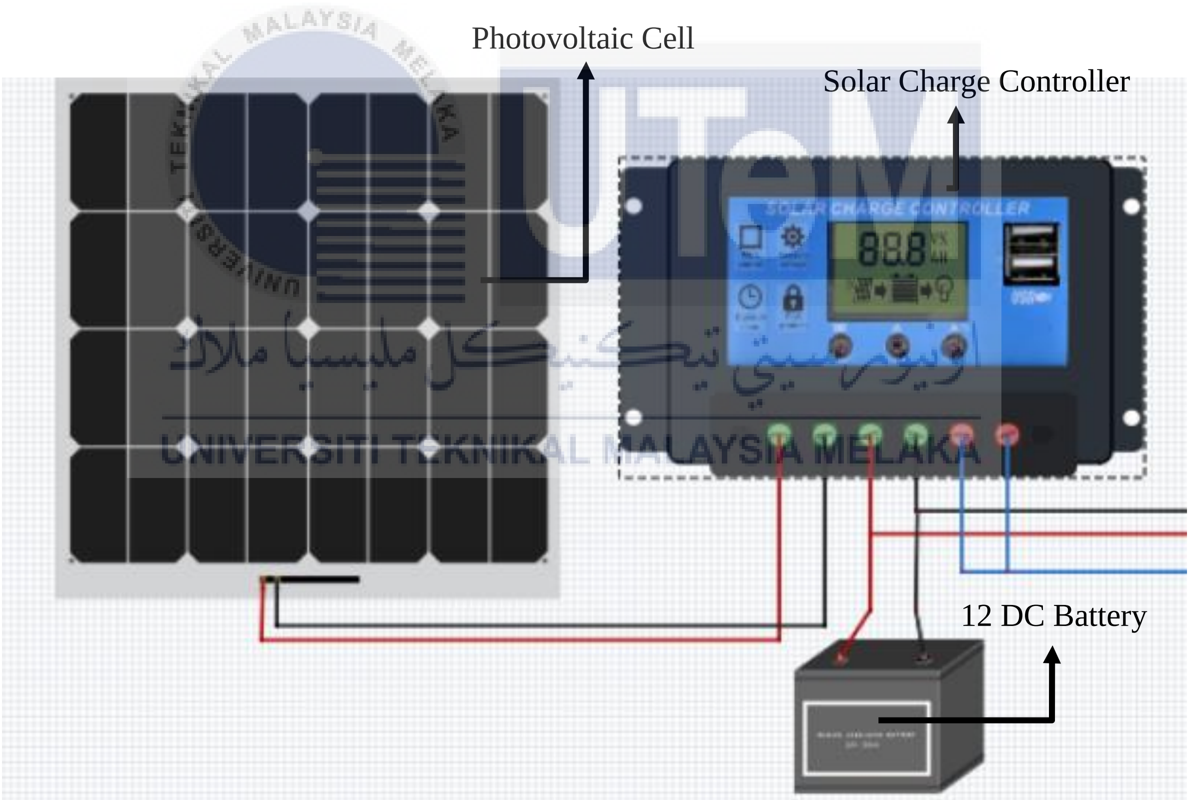

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Figure 3.2: Circuit diagram power supply

3.4 Parameters connection design

This study's process is the systematic integration of humidity, pH and water level sensors into an Arduino rev 3 for monitoring system. The first step involves physically attaching sensors to the Arduino by means of exact wire layouts. Next, power is applied to the Arduino platform to enable ongoing data collection. Then, to read and analyze sensor data, Arduino code is created, integrating necessary libraries to ensure smooth connection. Procedures for calibration are used, with special attention to the pH sensor, to provide precise and trustworthy results. The Arduino Serial Monitor allows for the real-time monitoring of sensor data, and it may be combined with 20x4 LCD display for visual representation. Thorough testing and fine-tuning processes are carried out to confirm the system's operation and improve its precision. Figure 3-3 shows the wiring diagram for 3 parameters in this project.

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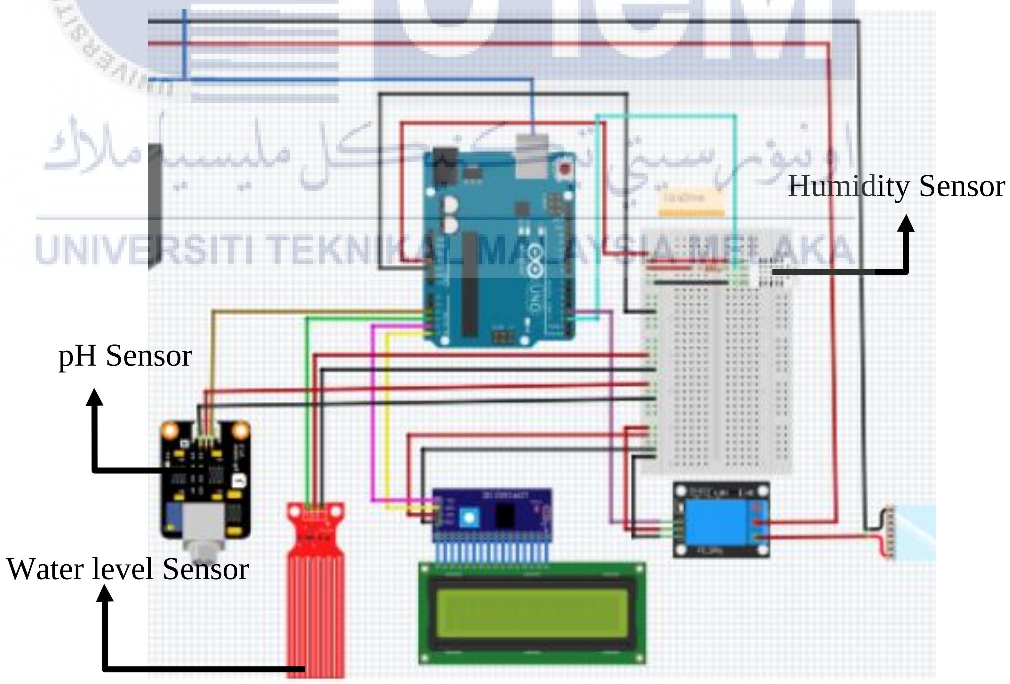

Figure 3.3: Wiring diagram parameters

3.4.1 Peltier

In addition to solar radiation, Peltier heaters are used to generate heat and raise the water's temperature to support the thermal performance that sunlight is not capable of achieving. The Peltier effect is a phenomenon that occurs at the junctions of these materials. When the electric current passes through the junctions, it causes one side of the device to absorb heat energy from the surroundings (the cold side) while the other side releases heat energy (the hot side). This creates a temperature gradient across the device, with one side becoming cold and the other side becoming hot. Figure 3-4 shows the Peltier module.

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Figure 3.4: Peltier module as Thermoelectric power

Table 3-1 shows the data sheet for Peltier Module.

Table 3.1: Data Specification for Peltier Module

Input Voltage
• **12v DC**
Temperature Range
• **-30˚C to 200 ˚C**
Rated Power
• **50Watt to 72 Watt**
Material
• **Ceramic**

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3.5 Project Development

The creation of a solar still involves many crucial procedures. First, come up with concepts and evaluate how effective they are. Next, create a problem definition that makes it very apparent what must be done. Next, use design tools like TinkerCAD to create precise models, then test them. Next, build a prototype, test it, and make any required modifications. After the design is finished, arrange and set up the production process. The solar still is tested in its actual environment after installation. Make careful to monitor and modify it frequently to ensure optimal performance. Lastly, provide continuing upkeep and assistance to make sure it keeps working correctly over time. The efficiency and durability of the solar still are ensured by this meticulous process. Figure 3-5 shows the process of development of triangular solar still.

Figure 3.5: Project development of triangular solar still

A triangular solar still is a device that uses controlled evaporation and condensation to cleanse water using sun energy. A triangle-shaped structure with a clear top surface that slopes 22^{o} and a collection container at the bottom is the usual design of a triangular solar still. The foundation of the still is where the water to be cleansed is poured and gathered. The top surface is transparent, letting light into the still. The water within warms up in the sun and evaporates. Water vapor rises and condenses on the inner surface of the triangle's sloping top surface as the water evaporates. The droplets of condensed water then cascade down the sloping surface, gather at a lower location and are guided into the collection container. Usually, the condensed water that is recovered is devoid of pollutants and impurities that were left behind from the evaporation process. As the water evaporates, any leftover pollutants or impurities, like salts or minerals, are left behind in the bottom of the still, having the purifying effect.

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3.5.1 Design software

Numerous designs exist for solar stills, each with pros and cons. The design chosen for the project was a transparent glass triangle-shaped solar still with a square base, height of approximately 200 mm, and base measurements of roughly 540 mm by 500 mm. The inclined cover of the solar will still be around 22° since the height is angled to trap water vapor, which then swiftly falls to the edge of the solar still to the base. To produce the triangular solar still, identify all measurement which can be compare be more accurate and get better results. To get high of solar still glass calculate. Equation 1 shows the calculation for measurement triangular solar still.

$$\frac{adjection}{opposite} = \tan\alpha \tag{1}$$

$$\frac{540\ mm}{200\ mm} = \tan\alpha$$

$$\alpha = 21.82°$$

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3.5.2 Project Structure Design

The field of solar stills encompasses a variety of designs, each of which offers a unique set of benefits and drawbacks. Imagine the base of the solar still being shaped into a triangular with dimensions of around 200 mm in height, 540 mm in width, and 500 mm in length. The mission at hand necessitated a careful selection of this particular setup. The solar still makes sure that water vapor finds its optimal path, easily condensing and cascading towards the edges, eventually reaching the base by decreasing an inclined stance at a 22° inclination. The body of the solar still, which was smartly constructed from galvanized steel and reinforced with wooden blocks, works well as a container for collecting and using thermal energy from the sun. Figure

3-6 & Figure 3-7 show the Triangular Solar Still all of view and measurement from TinkerCAD software.

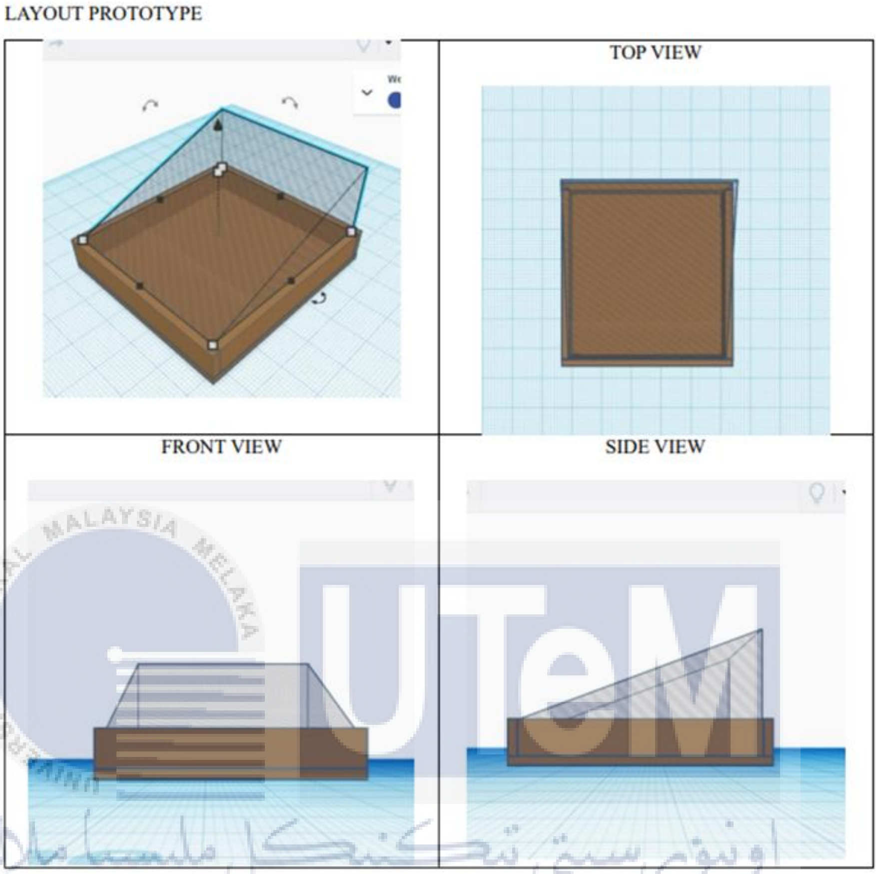

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Figure 3.6: View of Triangular Solar Still

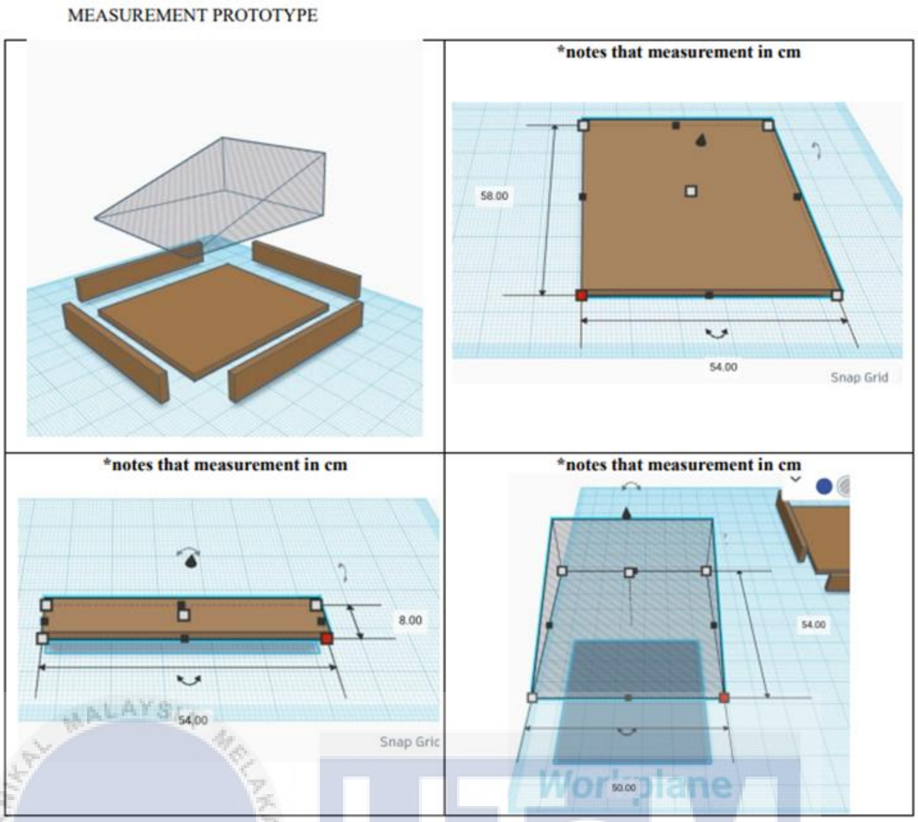

Figure 3.7: Measurement of Triangular Solar Still

3.6 Evolution of Triangular solar still

To achieve the optimum evaporation and condensation performance, enhance the efficiency of vaporization and ensure the reliability of structure for long term durability, some various parameters from literature survey used to develop into solar still design. All the descriptions must be considered to optimize the solar still’s functionality. Figure 3-8 shows the component assembled for triangular solar still.

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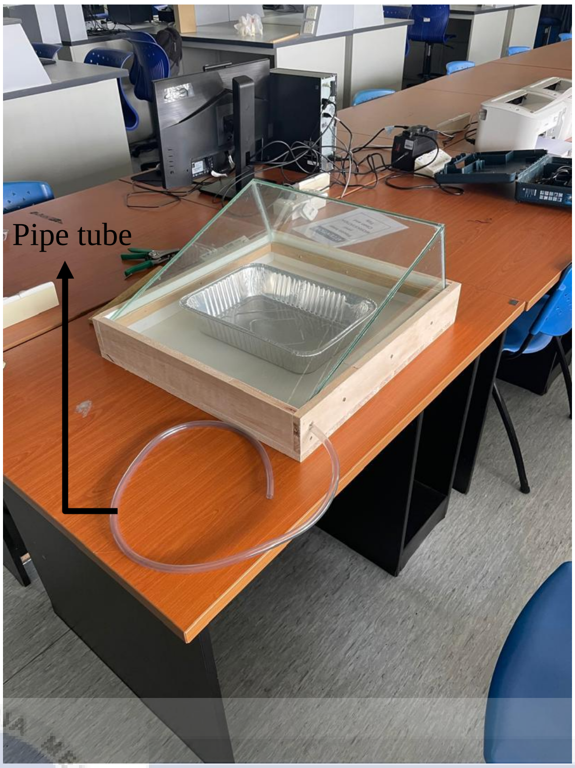

Figure 3.8: Evolution of triangular solar still

The targets of solar still development have been to achieve high stability, cheap cost, traditional form, and high efficiency. Low-cost, easily sourced materials like plastic and glass, combined with a straightforward pyramidal or rectangular shape, can reduce costs without sacrificing the structure's ability to withstand environmental stresses. In addition to being recognizable and simple to operate, a traditional form like the pyramidal design maximizes sun absorption and condensation. Utilizing dark materials to improve heat absorption, efficient insulation to reduce heat loss, and optimized condensation surfaces to increase water yield all contribute to high efficiency. This method guarantees that the solar will always be reasonably priced, strong, simple to make, and incredibly efficient at purifying water. High efficiency in solar still results influenced with the evaporation process, which lead to adequate vapor formation. Sunlight exposure, glass inclination and weather conditions are considered as the factors to get high efficiency of solar still.

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3.7 Recycle agriculture waste to porous material

In this project, corn husks are one of the porous materials used. Through the journals that have been referenced, corn husks have high thermal to help the process of evaporation and condensation. The corn husks, also known as agricultural waste, have been dried in the sun and left under the sun for three days. To produce this project, 3 husks of corn weighing 800 grammes were used. The presence of pores in the corn allows the water production rate to be higher compared to non-porous materials. This material is useful for evaporation because the heat applied to corn husks can cause the water within it to evaporate. Corn husks have a porous structure with a large surface area. This permeability allows for increased contact between the corn husks and the surrounding environment and assisting evaporation. The large surface area helps in raising the exposure of moisture to heat, leading to faster evaporation rates. Before starting to test the solar still, 0.75L tap water filled with corn husks in aluminum container. The water quality for this mixing material is 6.79 pH detected by pH sensor. Figure 3-9 shows the picture of corn husks mixing with tap water in an aluminum container.

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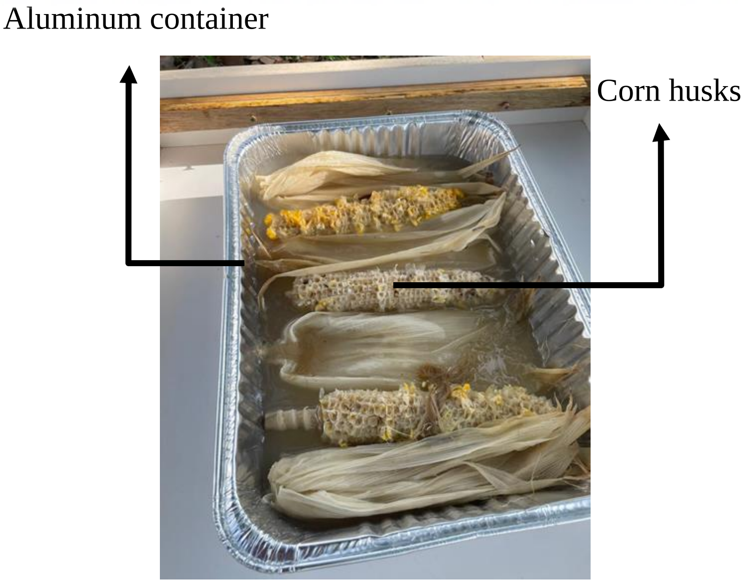

Figure 3.9: Corn husks mixing with tap water

3.8 Monitoring and Controlling Peltier effect using temperature relay

Enhancing the functionality and performance of the distillation process may be achieved by integrating electrical components such as temperature controls with the solar still. A solar still's temperature controller's primary responsibility is to monitor and regulate the inside temperature to ensure ideal condensation and evaporation. A solar still's efficiency can be increased by maintaining a temperature that maximizes water evaporation while minimizing heat loss. The controller was programmed to maintain a specific temperature range, above or below which a heating element or cooling process would be activated, respectively. The optimal temperature range for most sun stills is between 50 and 85°C. To measure evaporation temperature properly, a temperature sensor is installed in a solar still. It is also crucial to shield the sensor from direct sunshine. Because solar power heating components view this improvement as an energy source, a passive solar still becomes an active solar still. Higher yields of distilled water are produced by maximizing the water production rate via the maintenance of the ideal temperature. In the thermoelectric approach, Figure 3-10 illustrates how the W1204 temperature controller is coupled to a Peltier for the heating process.

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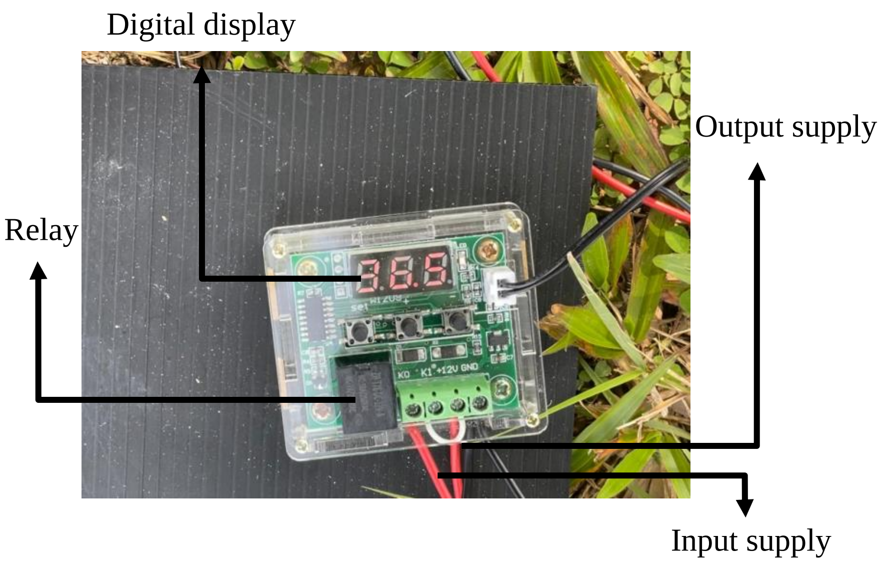

Figure 3.10: Temperature controller monitor and control Thermoelectric

3.9 Monitoring ambient temperature around Triangular Solar Still

The thermoelectric Peltier thermoelectric is connected to the output of the solar charge controller. A temperature controller is used to manage the current flowing through the Peltier module, preventing thermoelectric overheating by maintaining a steady temperature within the ideal range for evaporation. Maintaining the heat produced by the Peltier module in a solar still requires the use of appropriate thermal insulation. To increase the effectiveness of water production, more heat can be dissolved on the cold side of the Peltier using a heat sink. The aluminum container's bottom is where this Peltier module is located. A temperature sensor will detect this heat and monitor and regulate the temperature to prevent overheating. This triangular solar still is more dependable and efficient, particularly in fluctuating weather circumstances, thanks to the thermoelectric principle, which enables an efficient heating process. The temperature start rise those results in a functional Peltier module is seen in Figure 3-11.

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Digital Thermometer

Figure 3.11: Temperature surrounding triangular solar still

3.10 Monitoring evaporation and condensation process

The quality of the water that is generated is another important factor. The solar still works by evaporating water with the help of solar radiation, collecting waste products in the process, and then condensing the vapor back into liquid water. In the course of the evaporation and condensation process, the triangle solar still needs to effectively eliminate pollutants, toxins, and pathogens. Monitoring the water's temperature, sun intensity, surrounding temperature, and humidity are necessary to determine the effectiveness of the evaporation rate. Tests for water quality can be performed to measure the concentrations of bacteria, dissolved solids, and other contaminants. To evaluate the quality of the water generated, a Ph sensor will be used to test the water. If the pH is close to 7, it means the water is safe and clean. Figure 3-12 illustrates how the evaporation process began on a bright day.

Triangular Solar Still

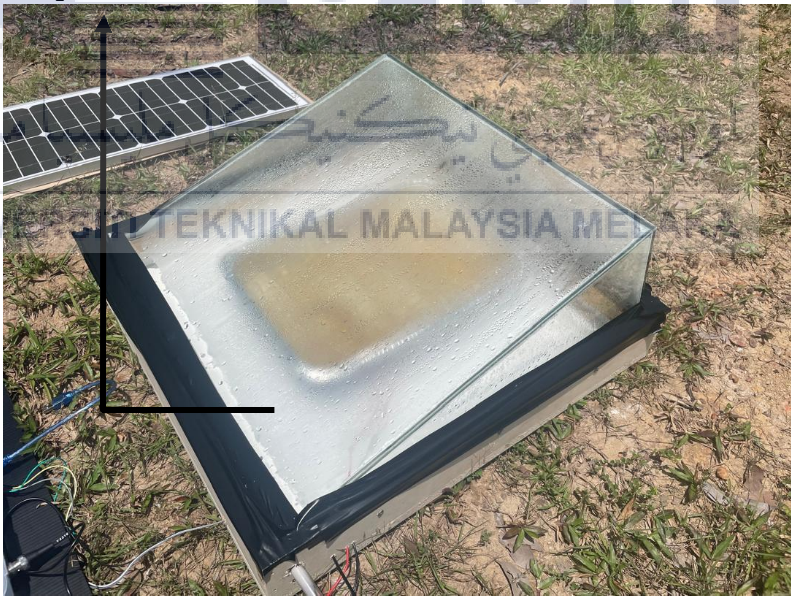

Figure 3.12: Evaporation process started at sunny day

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3.11 Data recorded every 1 hour when testing began

The pH of the generated water may be measured to ascertain its cleanliness. A lower pH value denotes greater water quality. Cost is another crucial factor to consider. This includes the price of the still, upkeep, and energy used throughout the process. A triangle solar still's effectiveness can be impacted by a number of variables, including humidity, sunshine intensity, and the still's dimensions. Since each of these elements affects the pace of evaporation, it is crucial to keep an eye on them all. The characteristics of the solar still were obtained and recorded from LCD monitoring every hour, as shown in Figure 3-13.

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Figure 3.13: Data recorded every 1 hour

MATLAB software was utilized to create the graph showing how temperature and humidity affect the rate at which water is produced in this triangle solar still after all the data had been gathered and documented. Figure 3-14 illustrates how the MATLAB software imported the data gathered from Microsoft Excel and encoded certain commands to run the graph in Appendices B.

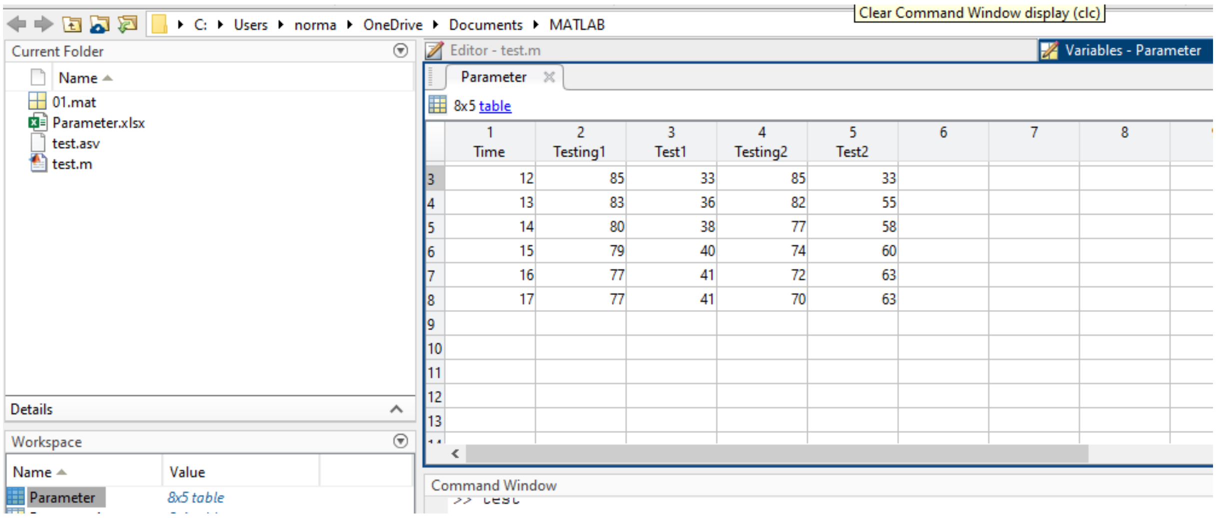

Figure 3.14: Data encoded in MATLAB Software

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3.12 Summary

This chapter covered all the scope of the project's objectives to identify and investigate all the factors that influenced the vaporization. The project methodology and stage-by-stage to develop the prototype. Reduced Angles 22^{o}: To maximize solar absorption, increase the surface area exposed to sunlight. They could, however, need greater base areas. Compact Designs: Usually with a base area of around one square meter, these are perfect for individual or small-scale application. Portability: Smaller devices are more suited for distant or emergency use since they are frequently made to be portable. Aluminum containers were chosen because they have a high heat conductivity and can absorb solar radiation, which speeds up the evaporation process. Glass: This clear cover lets in the lightest possible while producing a greenhouse effect within the distiller. Reflective Materials: Occasionally used around the base to increase the distiller's effectiveness by directing more sunlight into it. Silicone tape is used to maximize the effectiveness of the condensation process by sealing connections and edges to stop heat loss and make sure the system is airtight. Maintenance: Easy-to-clean surfaces, replaceable parts, and smooth surfaces are examples of materials and design choices that promote easy maintenance. Water filtration may be effectively and economically accomplished with triangular solar distillers. These distillers may maximize water output and dependability by optimizing the aspect angle, using suitable materials, and concentrating on insulation and design simplicity. They are a sustainable choice for private and communal usage because of their capacity to capture solar energy, especially in isolated or resource-constrained areas. All these components utilized to make the solar still are thoroughly discussed regarding their functionality and specific operation.

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CHAPTER 4:

RESULT & DISCUSSION

In this chapter, the project's outcomes will be discussed, including those that involve a comparison of the traditional solar still approach with a triangular-shaped solar still supported by a thermoelectric system to create clean still water. The parameter that needs to be examined is the sunlight radiation that the triangle's shape absorbs in order to create the temperature and humidity that are ideal for the evaporation and condensation processes. All the data from the result will be analyzed graphically to assess the effectiveness of the thermoelectric system to the solar still.

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4.1 Performance Analysis

Evaluation of the triangle solar still's performance comprises assessing the rate of vaporization and the efficacy and efficiency of water production. The rate at which water is produced is frequently used to evaluate its performance. In general, a few variables, including sun radiation, surrounding temperature, humidity, and solar still form, affect how quickly water becomes pure. Since sun exposure affects water production, solar radiation is the most significant factor. In a solar still, the evaporation process is caused by the heat of the sun. Peak temperatures in sunny regions throughout the daytime enhanced heat production and thermal processes that might cause water to evaporate. However, the performance of a solar still can be affected by changes in the weather, location, and sun radiation during the day. Figure 4-1 shows the testing for Triangular Solar Still.

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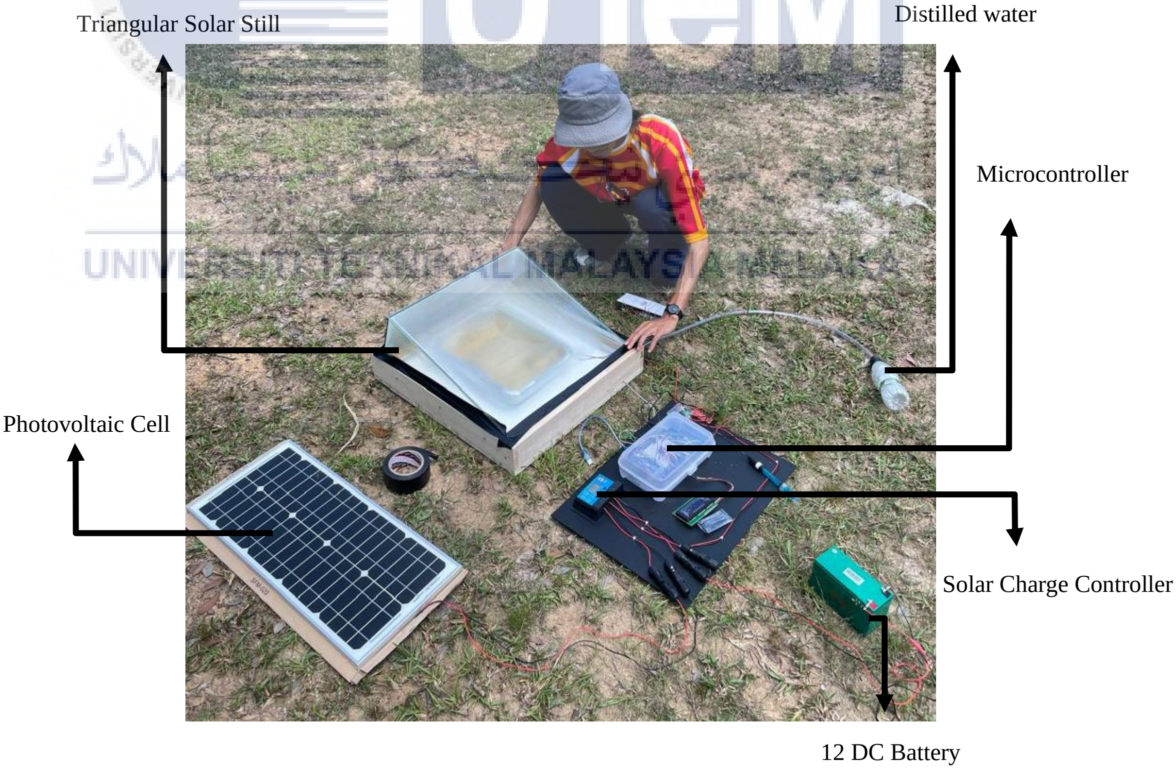

Figure 4.1: Testing for Triangular Solar Still

4.1.1 Data collection

The whole setup and data gathering procedure for this study will be combined and entered computations to determine the value. A solar still is a part that collects distilled water by using solar energy to evaporate and condense water. By comparing the amount of distilled water produced to the amount of solar energy required, one may assess the efficiency of a solar still. The equation in Table 4-1 used to analyze the effectiveness of water evaporation rates:

Table 4.1: Data collection for distilled water test in solar still

Initial water volume in container	**750 ml**
Time period, t	12.00 – 17.00 (5 hours)
Surface area of glass exposure, A	$500mm^2$
Solar irradiance from panel to solar still	$\frac{kWatt}{mm^2}$
Volume of distilled water, V_d	Initial water – Final water
Water evaporation rates, W_r	$\frac{Vd}{A \times t}$
Total energy from solar panel, E	$P_{solar} \times t$
Latent of heat vaporization of water, L_v	(0.63 kWatt/L)
Efficiency of water evaporation rates, η	$\frac{Wr \times Lv}{E}$

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4.1.2 Data gathered and tabulated

To observe the efficiency of triangular solar still, this project used two different variable manipulation which are testing passive solar still and active solar still. For passive solar still just only direct from sunlight while active solar still produce by adding thermoelectric concept to help heating process of mixed ingredients in solar still. All the data were collected in testing 1 and testing 2 every 1 hour that start from 12.00 pm until 17.00 pm. The data were collected by recording the LCD monitoring and key in the information into excel to analysis the project outcome. Table 4-2 shows the data collected for testing 1 and testing 2 for triangular solar still.

Table 4.2: Data collected for testing 1 and testing 2

Method	**Testing 1**		**Testing 2**	
Thermoelectric	No		Yes	
Time	Humidity (%)	Temperature (°C)	Humidity (%)	Temperature (°C)
12.00 pm	85	33	85	33
13.00 pm	83	36	82	55
14.00 pm	80	38	77	58
15.00 pm	79	40	74	60
16.00 pm	77	41	72	63
17.000 pm	77	41	70	63

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4.1.3 Analysis data that influenced evaporation rates

Analyzing the characteristics that were seen to help the triangular solar still perform better is crucial. The graph's data indicates that improving the thermoelectric idea will raise the solar still's environment's temperature and humidity. Because water droplets form when the ideal temperature and humidity can be regulated and maintained, producing the evaporation process is crucial. The triangle solar still temperature and humidity graphs for tests 1 and 2 are displayed in Figures 4-2 and 4-3. Using thermoelectric ideas, a slope graph contrasting active and passive solar stills would show clearly different efficiency gains. The gently sloping representation of passive solar stills shows how they rely on sun energy to do their water distillation. Under ideal sunlight circumstances, this slope exhibits modest water production; nevertheless, it may exhibit reductions during cloudy or low-light times because of decreased rates of heating and evaporation. Besides, thermoelectric active solar stills have a steeper slope, which indicates far higher water production rates. Their capacity to supplement solar energy with extra heating and cooling methods provided by thermoelectric modules is demonstrated by this steep slope. Because of this, these systems continue to produce large amounts of water even in the absence of sunshine, assuring reliability and lowering reliance on the weather. The operational benefits of active solar stills with thermoelectric technology in attaining dependable and efficient water distillation are adequately shown by such graphical depiction. From graph, the difference between passive and active solar still has been proven that water production can be improved when using thermoelectric concept.

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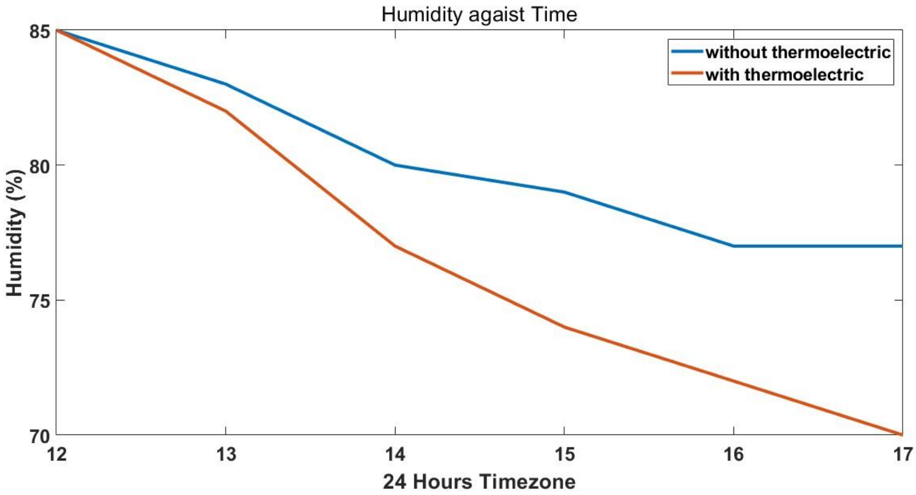

Figure 4.2: Humidity against Time

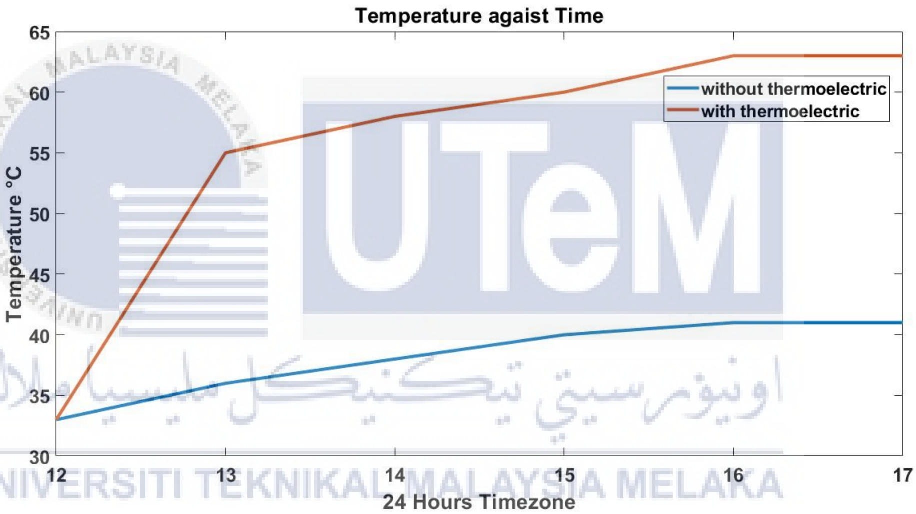

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Figure 4.3: Temperature against Time

4.1.4 Analysis of distilled water volume

The water purifier was brought into the lab to measure the water's volume and quality after purifying distilled water without thermoelectric power in test 1 and distilled water with thermoelectric power in test 2. This observation is important to prove that by maintaining the optimal humidity and temperature of solar still will influence the volume of water and quality of water. Table 4-3 shows the differences between both tests for distilled water volume. The increment by adding thermoelectric power into triangular solar still is 42 ml. By using water level sensor that has been calibrated, the volume of water was measured and to prove the efficiency of sensor we put the water purify into a beaker. Figure 4-4 and Figure 4-5 show the volume of water after finished the testing 1 and testing 2 have finished.

Table 4.3: Differences distilled water volume for test 1 and test 2

Triangular solar still	**Before**	**After**
Test 1 without thermoelectric	750 ml	68 ml
Test 2 with thermoelectric	750 ml	110 ml

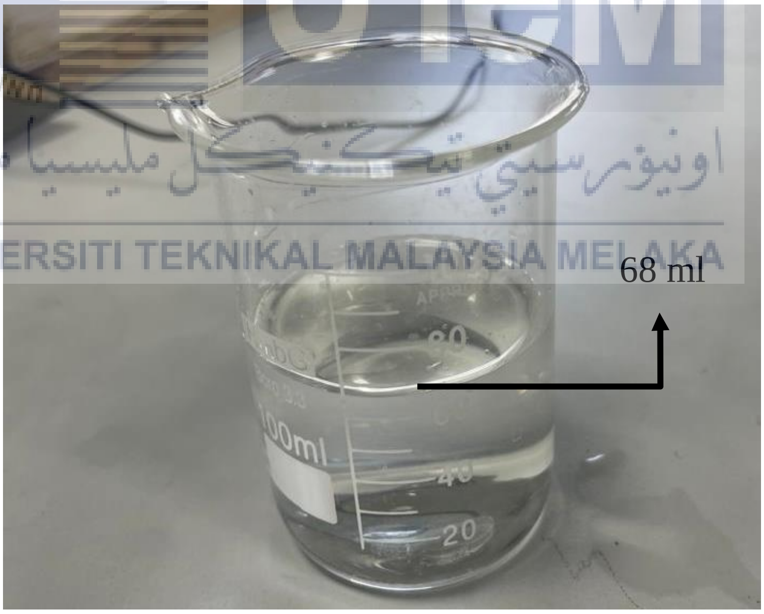

Figure 4.4: Volume of distilled water for testing 1

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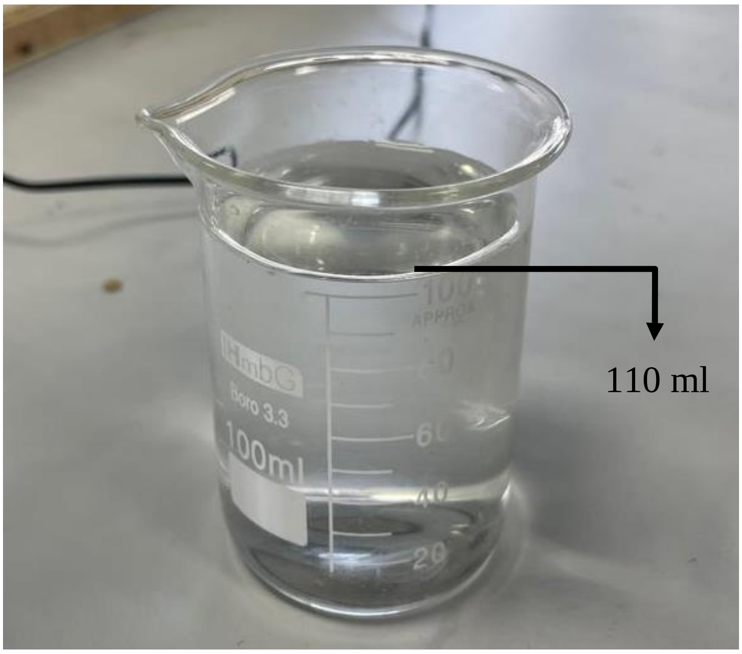

Figure 4.5: Volume of distilled water for testing 2

4.1.5 Analysis of quality of distilled water

For the quality of water, a pH sensor was used to detect the cleanliness of water. The pH sensor was calibrated and tested from buffer solution for starting with 7 pH. To confirm the quality of water, a pH indicator has been used to see the real quality of water and compared it to the pH sensor that has been calibrated. This is very important because purified water needs to be treated and must be cleaned before use to avoid some disease. Figure 4-6 shows the quality of water for testing 2 by using pH indicator. All the parameters were displayed in LCD monitor to confirm that each sensor was perfectly functioned to detect their specifications. Figure 4-7 shows the result for testing 2 which uses thermoelectric effect in LCD display.

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Figure 4.6: pH indicator for distilled water

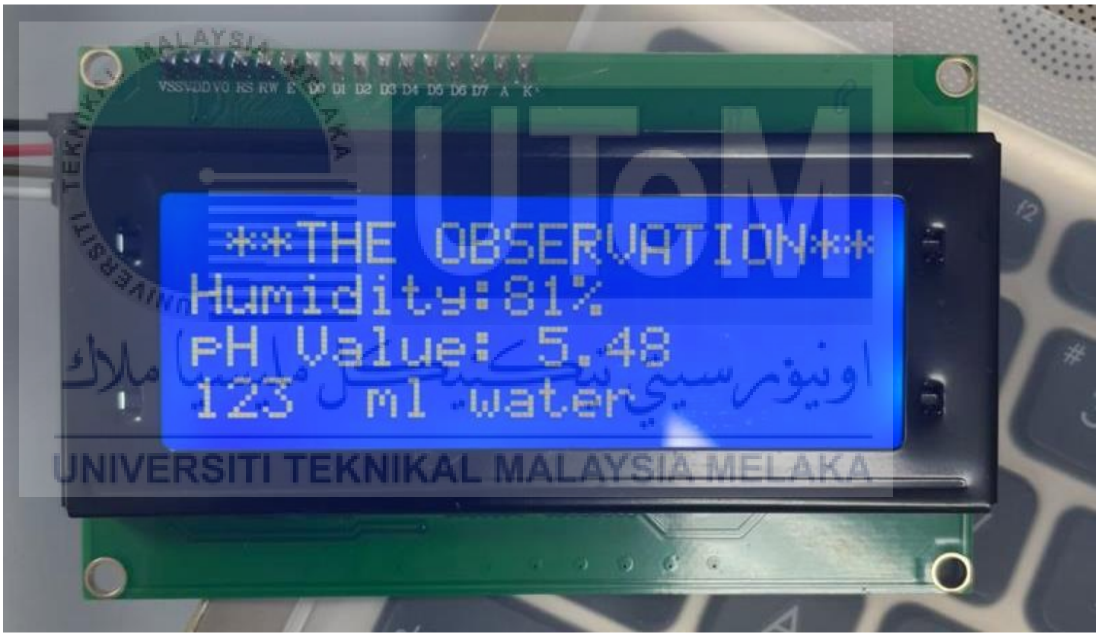

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Figure 4.7: The observation of testing 2

4.1.6 Efficiency of design performance for evaporation rates

From an initial 750 ml testing 1, 60 ml of water were produced using a 100-watt solar panel over the course of five hours, according to the water evaporation procedure of the solar still. The water evaporation rate was determined to be 0.024 liters/m^2/hour with a solar still surface area of 0.5 m^2 and an average sun irradiation of 0.8 kW/m^2. The efficiency of the solar panel was calculated using the latent heat of vaporization of water, which is equivalent to 0.63 kWh/L. The total energy input from the panel was 0.5 kWh. Although there may still be an opportunity for system optimization to further boost efficiency, the resultant efficiency of around 3.02%.

For testing 2, an initial 750 ml was tested, and 110 ml water were produced using 100-watt solar panel over the course of five hours, according to the water evaporation procedure of the solar still. A 50-watt Peltier device and a 100-watt solar panel together provided 0.75 kWh of energy over the course of five hours. 0.044 liters/m^2/hour with a surface area of 0.5 m^2 evaporation rates were measured, and average solar irradiance is 0.8 kW/m. The latent heat of vaporization of water, which is equivalent to 0.63 kWh/L. The efficiency of water evaporation rates by adding Peltier effect is 3.70 % which expected as in theory that higher than testing without adding heating process. This relatively shows that the Peltier effect contributes to the distillation process significantly remaining optimal to increase the efficiency of the solar stationary system. Figure 4-8 shows the bar chart that comparison that will be see the output of efficiency of water evaporation process. Table 4-4 shows the summary of calculation to analyze the performance of solar still in terms of water evaporation rates.

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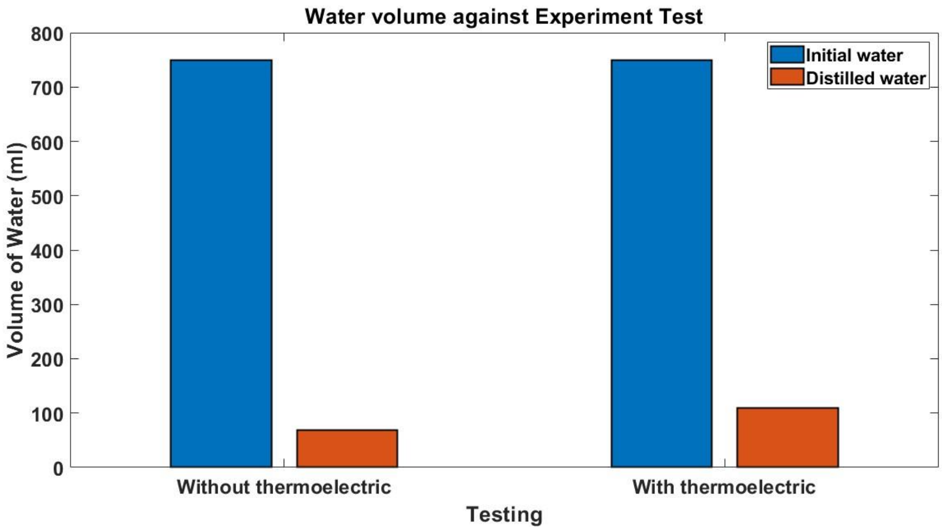

Figure 4.8: Comparison of initial water and volume of distilled water

Table 4.4: Summarize of analyze of water evaporation process

Data collection	Testing 1	Testing 2
Initial water in container (L)	0.75	0.75
Volume of distilled water (L)	0.06	0.11
Time period (hour)	5	5
Surface area glass exposure (mm²)	500	500
Solar irradiance (kW/m²)	0.8	0.8
Water evaporation rates (liters/m²/hour)	0.024	0.044
Total energy (kWatt/hour)	0.5	0.75
Latent heat vaporization (kWatt/L)	0.63	0.63
Efficiency of evaporation rates (η)	0.0302	0.0370
Percentage of evaporation rates (%)	3.02	3.70

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4.2 Analysis summary

The analysis of the test results provided valuable awareness into the impact of temperature, humidity, and various investigational factors on the water drop process and the production of clean and potable water. The evaporation process proved effective in drastically reducing the pH value from an initial reading of 6.89pH to 5.48pH, indicating the need for enhanced cleanliness and safety of the water. The project's primary objective focused on optimizing the evaporation rate to achieve the fastest production of clean water, which was achieved by utilizing the power of solar radiation.

To analyze the triangular solar still with Sustainable Development Goals (SGDs) is Goal 15: Life on Land. This goal focuses on protecting, restoring and promoting sustainable use of ecosystems and managing forests. The conversation of ecosystems ensured planetary and inland freshwater. Sustainable forest management promoted good management of forest and halting deforestation. Solar still can reduce firewood and charcoal usages for boiling water to make it safe as clean water. This will decrease the fuelwood demand and help in conserving plants and forest. In rural areas, clean water can be accessed through solar distillation which can support agriculture and vegetation. Triangular solar still can invest community by providing with sustainable and low-cost water purification system.

Besides, (SGDs) for this project is Goal 12: Responsible Consumption & Production. This aims to ensure the sustainability of consumption and production patterns, leading to reduced environmental effects and ensure social well-being. Solar still uses solar energy, a renewable energy to purify water. This method reduces dependence on non-renewable energy and promotes the efficiency of natural

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resources. By providing clean drinking water through solar distillation, bottled water usage can be reduced, which causes plastic waste to reduce. Additionally, this method does not produce toxic products. Solar distillation proves as alternative to traditional water treatment, such as boiling with non-renewable fuels or chemical treatment. This habit promotes more sustainable consumption.

(SGDs) next is Goal 7: Affordable & Clean Energy. This goal aims to make sure access to affordable, reliable, sustainable and modern technology energy for all. Solar distillation served as a simple and effective way to produce purified water using solar energy, which is a renewable resource. This is very beneficial especially in rural areas where access to modern sources services is limited. By fully utilizing solar energy for water purification, triangular solar still precisely contributes to raising the share of renewable energy in the global energy mix. The adoption of solar still advocates the development and use of clean energy technology. This will encourage investment in solar-based solutions and emphasize the potential of solar energy in focusing various human needs sustainably. Figure 4-9 shows the 17 Sustainable Goals Development adopted by United Nations.

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Figure 4.9: 17 Sustainable Goals Development

CHAPTER 5:

CONCLUSION & FUTURE WORKS

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5.1 Conclusion

In conclusion, the triangular solar still presents a capable solution for harnessing solar energy resources to produce potable water in rural areas. Its innovative design, illustrated by a triangular shape, maximizes the surface area exposed to sunlight, enabling efficient evaporation and condensation processes. By utilizing inexpensive and readily available materials such as transparent plastic or glass, the triangular solar still can be easily constructed and deployed. The triangular method and integrating a thermoelectric system and the corn husks, alongside real-time monitoring of water temperature and purity, the project overcomes limitations of conventional designs.

This project proves that the comparison between triangular solar distiller method in testing 1 and adding thermoelectric into triangular solar distiller method in testing 2 about an efficiency of design performance for evaporation process influences from any variable such as temperature, humidity, solar irradiation, surface area of solar still and energy absorbed from sunlight exposure through this triangular solar still. By doing some calculations, the difference between using thermoelectric and direct sunlight can be shows same as the theoretical stated that adding thermoelectric can improve the volume of water evaporation rates. The efficiency of design performance in terms of water evaporations using thermoelectric is 3.70% compared with direct sunlight only is 3.02%. As shown in this experiment, adding thermoelectric power to a triangular solar still increases the efficiency of water evaporation rates by 0.68%.

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Experimental results show that, under daylight conditions and using specific methods, the triangular solar still produces almost 100ml of water with a pH level ranging from 6.8 to 5.48. The quality of water is not the best result as expected in theory, but this considers that water is mixing with other contaminated because the corn husks were dried for 3 days. The water used in the experiment was combined with other polluted water sources rather than being utilized alone. The water quality may have been lowered by the opening of more contaminants brought in by this pollution. 3 days were spent drying the corn husks that were going to be employed in the filtration procedure. The husks' natural capacity to filter impurities may have been harmed by the drying process. While fibers and other naturally occurring, substances found in corn husks can serve as filters, continuous drying of the material may change its structure and lessen its filtration capacity. The husks' capacity to efficiently capture and retain pollutants may be diminished if they become brittle due to drying. These findings demonstrate the potential of the triangular solar still design in improving efficiency and output quality, contributing to the improvement of water shortage and the encouragement of sustainable water management worldwide.

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5.2 5.2 Future Work

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

- Optimization of design: Explore different variations of the conventional solar still's geometry, such as varying the angle and size of the panels, to determine the most efficient specifications. Software simulations and experimental testing can be conducted to recognize the optimal design parameters.

- Material selection: The choice of materials for the solar still's construction can greatly guide its efficiency and durability. Future work can involve testing and evaluating different materials, such as advanced solar-absorbing coatings, to enhance heat absorption and avoid heat loss.

- The impact of external factors: Studying the impact of external issues such as wind speed, humidity, and ambient temperature on the evaporation process will contribute to a deeper understanding and knowledge of the solar still's performance under various conditions

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APPENDICES

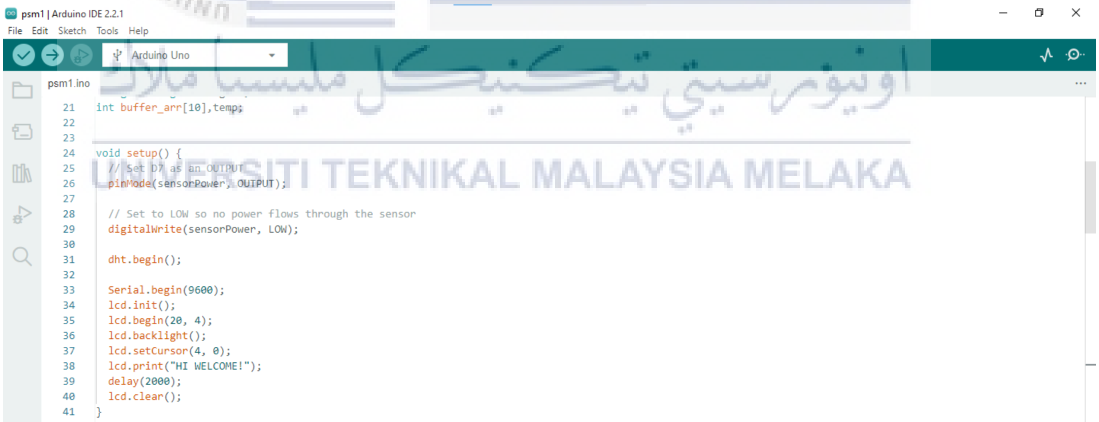
Appendices A


```
#include <LiquidCrystal_I2C.h>
#include <Wire.h>
#include <DHT.h>;
LiquidCrystal_I2C lcd(0x27, 20, 4);

//Constants
#define DHTPIN 6     // what pin we're connected to
#define DHTTYPE DHT11   // DHT 11
DHT dht(DHTPIN, DHTTYPE);
int h;  //Stores humidity value

// Sensor pins temperature
#define sensorPower 7
#define sensorPin A0
int val = 0;
// Sensor pins pH value
float calibration_value = 21.34;
int phval = 0;
unsigned long int avgval;
int buffer_arr[10],temp;

```



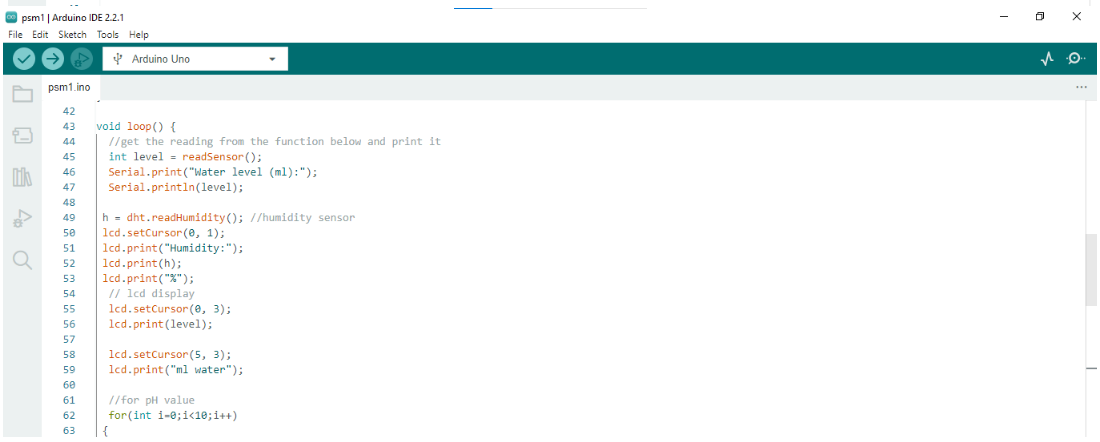

```
int buffer_arr[10],temp;


void setup() {
  // Set D7 as an OUTPUT
  pinMode(sensorPower, OUTPUT);

  // Set to LOW so no power flows through the sensor
  digitalWrite(sensorPower, LOW);

  dht.begin();

  Serial.begin(9600);
  lcd.init();
  lcd.begin(20, 4);
  lcd.backlight();
  lcd.setCursor(4, 0);
  lcd.print("HI WELCOME!");
  delay(2000);
  lcd.clear();
}
```




```

void loop() {
  //get the reading from the function below and print it
  int level = readSensor();
  Serial.print("Water level (ml):");
  Serial.println(level);

 h = dht.readHumidity(); //humidity sensor
 lcd.setCursor(0, 1);
 lcd.print("Humidity:");
 lcd.print(h);
 lcd.print("%");
  // lcd display
  lcd.setCursor(0, 3);
  lcd.print(level);

  lcd.setCursor(5, 3);
  lcd.print("ml water");

  //for pH value
  for(int i=0;i<10;i++)
 {
```

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File Edit Sketch Tools Help

Arduino Uno

psm1.ino

```
 lcd.setCursor(5, 3);
 lcd.print("ml water");

 //for pH value
 for(int i=0;i<10;i++)
{
buffer_arr[i]=analogRead(A1);
delay(30);
}
for(int i=0;i<9;i++)
{
for(int j=i+1;j<10;j++)
{
if(buffer_arr[i]>buffer_arr[j])
{
temp=buffer_arr[i];
buffer_arr[i]=buffer_arr[j];
buffer_arr[j]=temp;
}
}
}
```

psm1 | Arduino IDE 2.2.1

File Edit Sketch Tools Help

Arduino Uno

psm1.ino

```
float volt=(float)avgval*5.0/1024/6;
float ph_act = -5.30 * volt + calibration_value;
lcd.setCursor(1, 0);
lcd.print("**THE OBSERVATION**");

lcd.setCursor(0, 2);
lcd.print("pH Value:");
lcd.setCursor(10, 2);
lcd.print(ph_act);

 delay(1000);
}

//This is a function used to get the reading
int readSensor() {
  digitalWrite(sensorPower, HIGH);  // Turn the sensor ON
  delay(100);             // wait 10 milliseconds
  val = analogRead(sensorPin) / 3 ;   // Read the analog value form sensor
  digitalWrite(sensorPower, LOW);   // Turn the sensor OFF
  return val;             // send current reading

}
```

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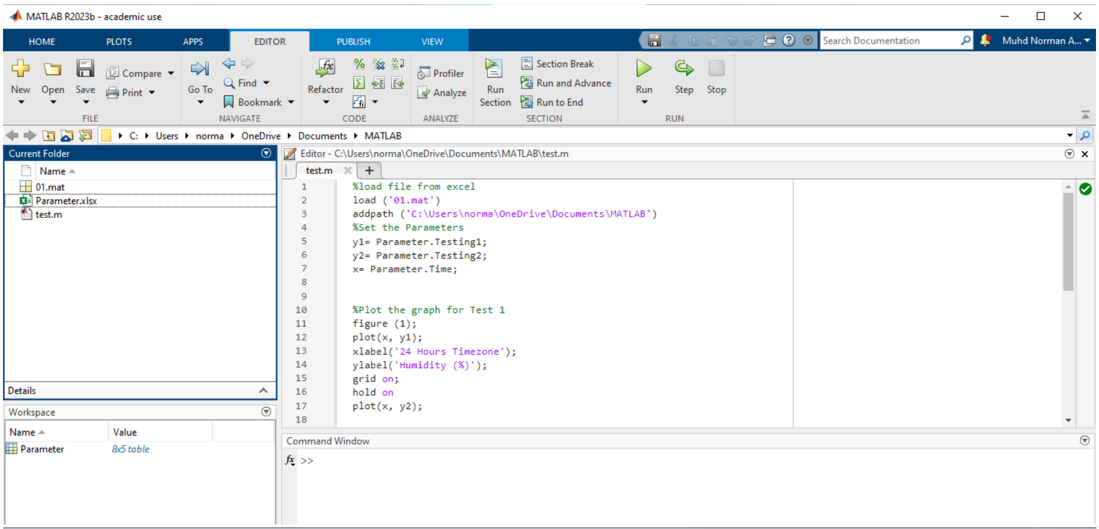
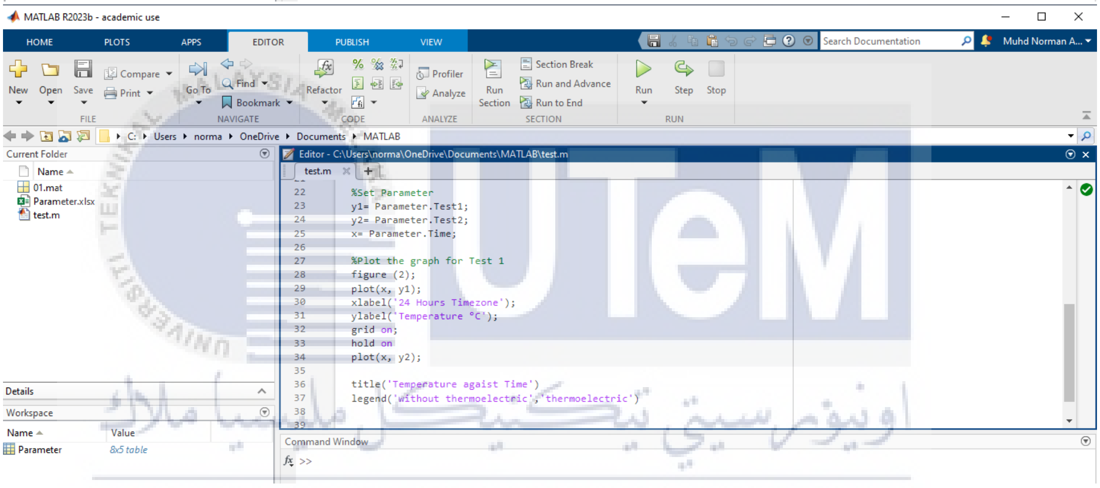
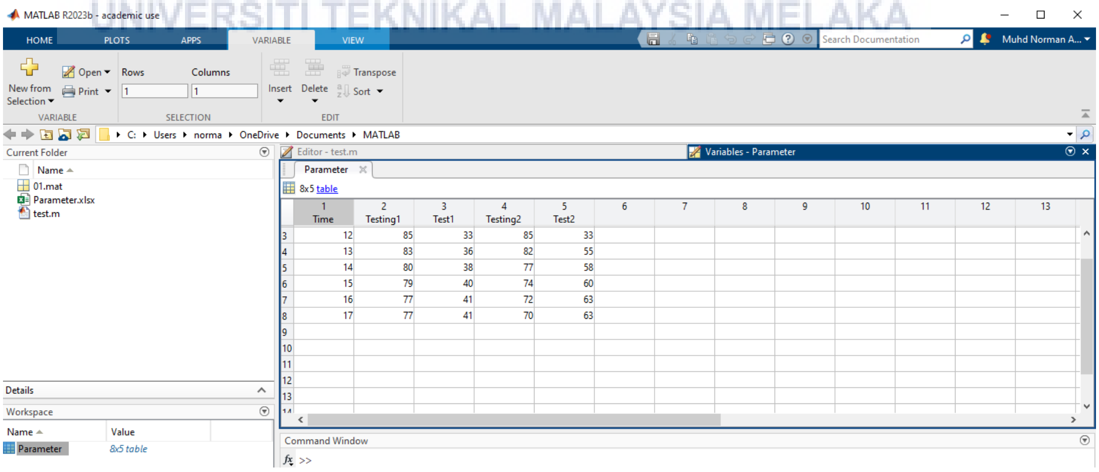
Appendices B







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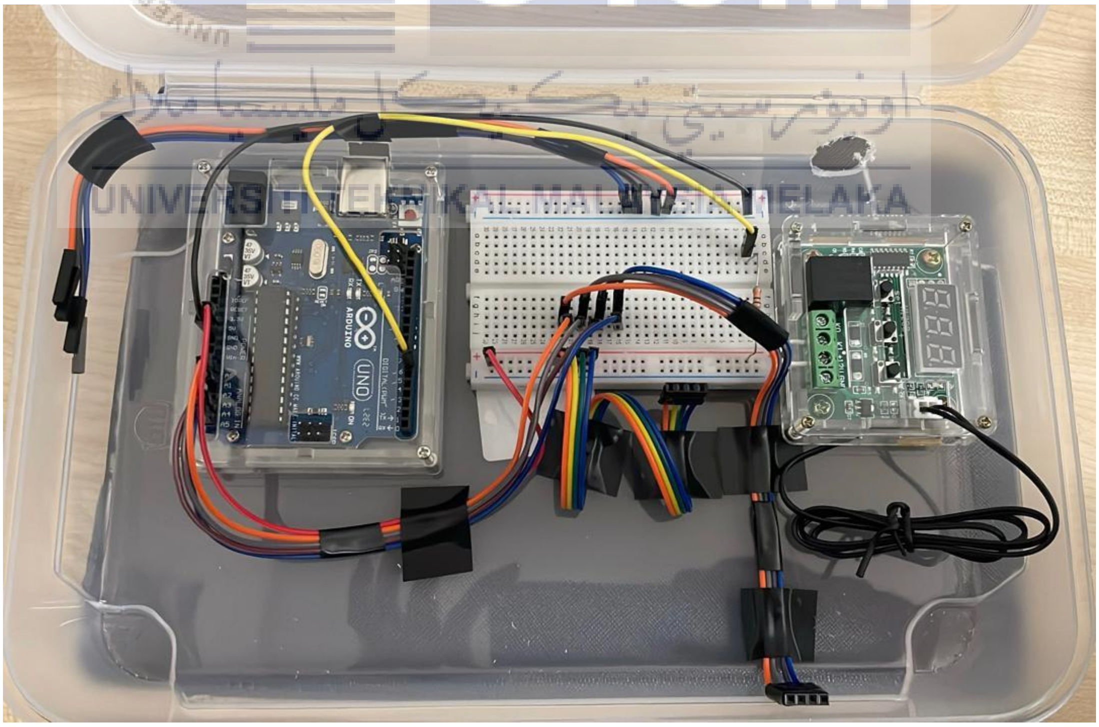
Appendices C



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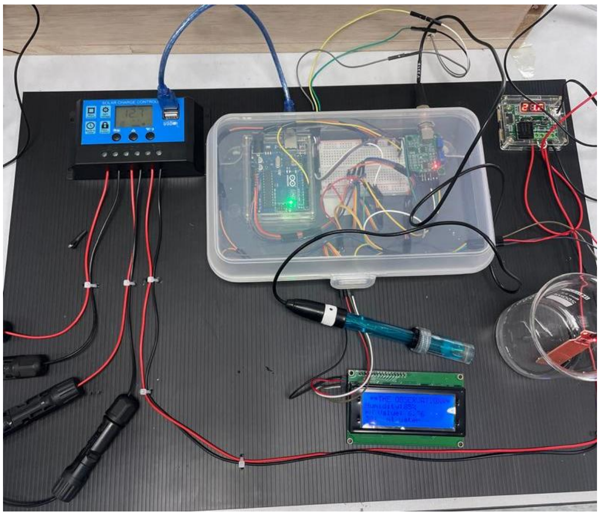

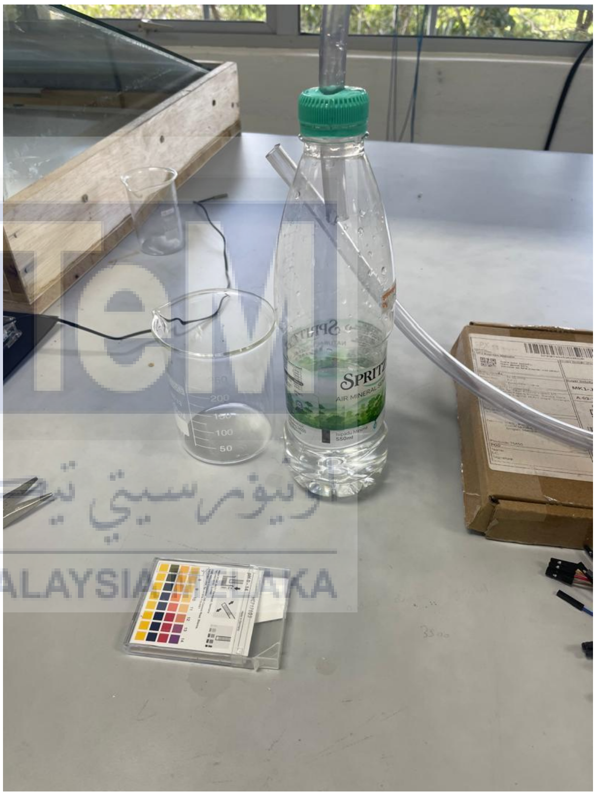

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