The potable water production using glass cover double slope solar still with a different heat absorption materials

By

Khouna Mohamed Khouna

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Supervisor :

Assoc. Prof. Dr.Hj. Khamaruzaman bin Wan Yusof

UniversitiTeknologi PETRONAS

Bandar Seri Iskandar

31750 Tronoh

Perak DarulRidzuan

Certification of Approval

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Approved by,

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(AP DR. HJ. KHAMARUZAMAN WAN YUSOF)

UniversitiTeknologi PETRONAS

Certification of Originality

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgement, and that the original work contained herein have not been undertaken or done by unspecified sources or person.

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(Khouna Mohamed Khouna)

ABSTRACT

Solar stills are straightforward method for acquiring refined water utilizing radiation from the sun. Some solar still models additionally upgrade the dissipation properties of the solar stills, for example, air velocity and water depth to produce larger amount of yield. The results showed that the performance of solar stills was improved through the increase in solar radiation. It was also determined that both internal and external reflectors are capable of increasing the amount of absorbed solar radiation on the basin liner. However, the distilled water produced by the solar still system is very limited. Therefore, this paper presents the experimental results of the performance of the solar still system. This experiment will be conducted in UniversitiTeknologi PETRONAS (UTP) solar field testing facility. The weather forecast and solar radiation intensity data will be obtained from Ipoh Meteo Department for the experiment. The parameters of the basin size, cover material and water depth are fixed. Generally, 3 types of experiments will be conducted:

- Black soil basin
- black painted basin
- Conventional solar still

When the water temperature increase the water production will increase, the water production from black painted basin solar still system is higher than both black soil and conventional solar still system. Water production from black painted basin solar still is 2.106 l/m², while black soil and conventional only produce 1.480l/ m² and 1.028l/m² respectively.

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CHAPTER 1

INTRODUCTION

Introduction

The water is the most profitable helpful resources for the humans, plants and creatures, all can't live without water, and we utilize the water for drinking, washing and cleaning, and additionally numerous different employments. The worldwide interest for crisp water has gotten to be substantially more of an issue than in past decades. The proposed model utilized as a part of this test will be potable water Production using glass cover double slope solar still with a different heat absorption materials which is significantly low in expense and can be utilized as a part of remote region. This task is concentrating especially on refining which is utilized as a part of numerous nations, particularly those with less access to fresh drinking water.

These freshwater ecosystems are facing numerous threats and challenges. In fact, the extreme climate nowadays also becomes a huge contributing factor to the eruption of freshwater supply in Asian country and Africa as well. The eruption supply of fresh water will give a major impact to the living in the remote area, where there are no piped water supplies. This will give a huge impact to all living thing and ecosystems especially humans. Recognising this, a research and study have been developed on producing the potable water using solar still distillation process. A solar still is a simple way of distilling water, using the heat of the sun to drive evaporation from humid soil, ambient air or any source of untreated water to collector plate. The water collected is clean and fresh. Hespanhol (1994) stated that the water produced from solar still system meet all the standard requirement of World Health Organisation (WHO) for drinking water quality.

To achieve this, a high intensity of solar radiation is needed, and Malaysia has a good potential in that area. Malaysia naturally has abundant sunshine and thus solar radiation. However, it is extremely rare to have a full day with completely clear sky even in periods of severe drought. The cloud cover cuts off a substantial amount of sunshine and thus solar radiation. On the average, Malaysia receives about 6 hours of sunshine per day.

Solar radiation is closely related to the sunshine duration. Its seasonal and spatial variations are thus very much the same as in the case of sunshine. Therefore, it has been a great challenge to this research, on how to generate the high scale of potable water, with the high rate of the production by the evaporation process. There are many previous research that have done before regarding the solar still system, but to increase the production rate, some new materials has been used In this research.

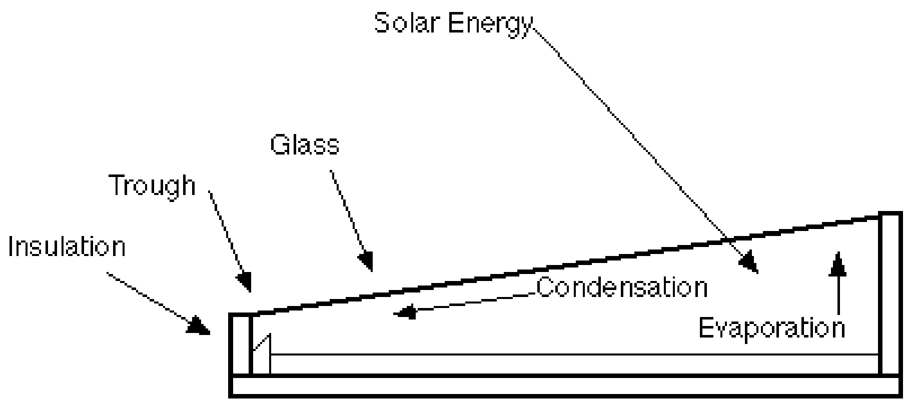


Figure 1: Basic solar still system

Problem statement

Clean and fresh waters production is decreasing globally, due to the pollution and several global issues. Though, to increase the productivity of the fresh and clean water is important to the mankind. On top of that, supplying the clean and fresh water to the rural areas has become a critical problem that we need to overcome. As clean and fresh water is important for human being, solar still can help in order to solve this problem, in order to purify the water to ensure the water supply is clean and fresh. During dry season, water interruption will occur. Thus, the solar still that available especially during the dry season will be used as a solution to the problem.

Objectives

Based on the problem statement, we realize that to produce the potable water using the solar still distillation system is possible but this research will emphasize on how to increase the rate of production of the potable water by the evaporation process. This research is giving an overview of the impact of the using of black soil and black painted in order to get the maximum production rate of potable water collected. This research also can provide community service for the farmers and the population of the remote area by providing potable water during dry season.

Listed below are the objectives of the project:

1. To investigate the potable water production improvement using a cost-effective glass cover double slope solar still with different absorption heat materials.
2. To produce much more potable water in the future.

Relevancy & Impact of Research

With references to the Problem Statement section, we know that clean and fresh water or so called potable water has become a global problem, where due to the pollution and other global problem such as war, and socio economic related problems. Nowadays, to get a potable water becomes a problem, including Malaysia.

With the high rate of population growth, demand of the potable water constantly increased, but at the same time, the supply is constantly decrease due to the extreme weather, excessive solar radiation and high intensity of heat. In July 2014, Malaysia has gone through a disaster where the water level of the pounding area all over the country gets lower due to extreme hot weather.

This research is focusing on how to produce the potable water by evaporation using solar still system towards the big scale, by high production rate to cater the needs of the end user. To achieve this, a double slope solar still with glass cover will be used to support the production rate by heating up the water. However, according to Badran (2007), the night production in the absence of solar radiation contributed to 16% of the daily output due to the differences in temperature between the cover and water, and the decrease of heat capacity. In terms of the research conduct of the project, it is not feasible for the student to conduct the experiment during night time. However, the feasibility of the overall project is within the students' grasp, where all the feasibility elements discussed later is provided. Therefore, the main significant of this research project can be summarized to effectively produced the potable water by increasing the evaporation rate, to ensure it can be implemented in a big scale, for the benefit of the mankind.

Feasibility & Scope of Study

This study will be focused on solar still system design and fabrication in order to get the maximum evaporation rate to produce the maximum potable water collected. All the parameters that affecting the solar still productivity and the potable water collected will be taken into consideration in order to vary the method used to achieve the objective stated. Generally, this experiment will be conducted using the passive solar still system

This passive solar still system will use 3 types of different basin, which is conventional and black painted and the other one is black sand. This experiment will help to determine how efficient the evaporation will be by using the different basin materials towards the system in order to increase the production of the potable water by evaporation process. Besides, different type of the basin will also determine the production rate in the passive solar still system. Therefore this research project is definitely feasible and scope of study in processing and interpreting the results is achievable within the conduct of Final Year Project I (FYP I) and Final Year Project II (FYP II).

CHAPTER 2

LITERATURE REVIEW

Solar Still System

The first scientist who developed a solar still for supplying pure water to a nitrate mining community in Chile was Wilson (1972), which was very popular and was in operation for more than 40 years. The solar still distillation system is environmental friendly and it can save a lot of money and time, in term of producing clean and fresh water.

It is supported by Kumar et al., (2009) where he stated that solar distillation is one of the good options to obtain fresh water at reasonable cost. Furthermore, solar distillation is an attractive alternative because of its simple technology, non-requirement of highly skilled manpower for maintenance, low energy need and can be used at any place without much problem. Tiwari et al., (2008) has stated that solar still are working on the process of distillation of brackish/saline water by utilizing solar thermal energy. Basically, solar still distillation system has two general types which are single slope and double slope. There are several factors that affecting the performance of the solar still distillation system, which is the water depth in the basin, basin size, and the basin material. Tiwari et al., (2008) stated that the thermal performance of solar still is affected by several design parameters like water depth, thickness of glass cover, insulation thickness, condensing cover material, type of solar collector, number of collectors, and also affected by climate change.

Nafey et al., (2000) had conducted a study on different material used as a basin to store the water in the solar still distillation system. He found that the productivity increased by 20% when using black rubber (10mm) thick as the basin material whereas the productivity also increase by 19% when using black gravel (15-20mm) size as the basin material. Solar still system divided into two, which is the active solar still system and passive solar still system. Passive solar still system is a system that fully utilizes the energy from the sun, whereas the active solid still system is a system that using other equipment to produce heat.

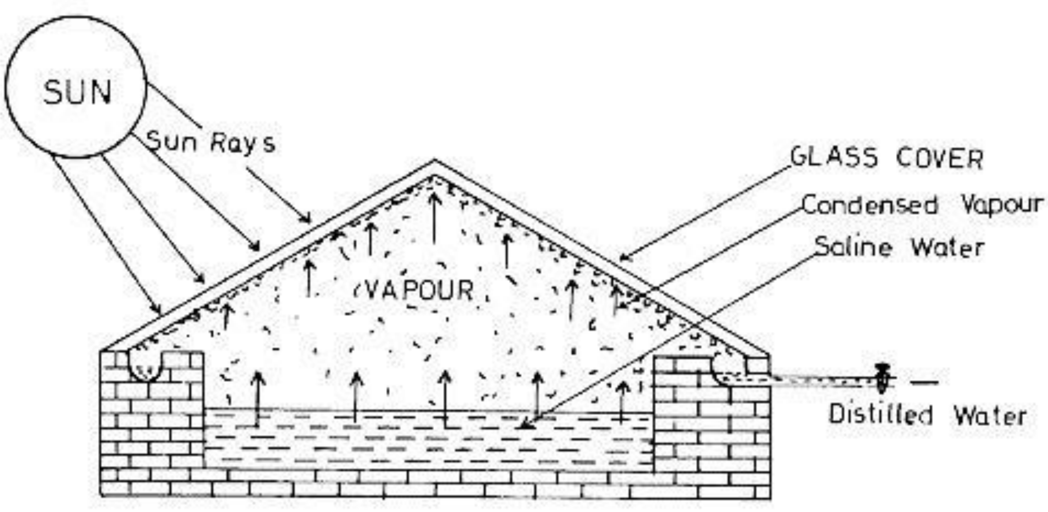


Figure 2: Sample of Double Slopped Solar Still Distillation System

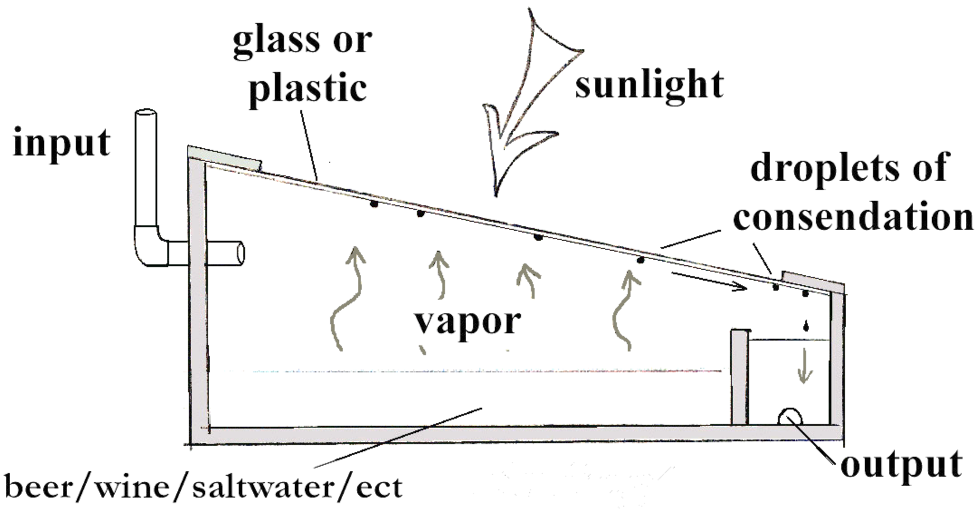


Figure 3: Sample of Single Slope Solar Still Distillation System

Performance of Solar Still Distillation System

Kumar et al., (1998) stated that the performance of solar distillation system is governed by the rate of evaporation from the water surface in the basin. This depends on water and inner glass cover temperature differences. This is supported by Vinoth et al., (2007) where he found that the condensation occurs due to the temperature difference not only on the glass surface but also on the four sidewalls, which can be cooled by water circulation through tubes attached on the wall surface for efficiency enhancement.

Table 1: Rate of Evaporation for Different Sample

Sml. no.	Time (s)	Avg. ambient temp. (°C)	Avg. water temp. (°C)	Avg. solar ins. (W/m^2)	Avg. wind speed (m/s)	Avg. relative humidity (%)	Rate of evap. (%)	Conditions
1.	6300	36.5	41.75	969.7	1.8	74	80.40	Tap water (with cooling)
2.	6300	36	40.58	940.5	1.8	73	82.83	Tap water (with cooling)
3.	7500	34	40.93	668.8	1.4	73	97.86	Tap water (without cooling)
4.	8400	33.7	38.87	508.87	1.2	72	98.32	Tap water (without cooling)
5.	9600	35	41.35	915.58	2.1	74	55.62	Seawater (with cooling)
6.	9900	34.5	41.17	844.86	2.4	75	58.27	Sea water (with cooling)
7.	11400	34.0	40.25	583.3	1.2	71	90.96	Seawater (without cooling)
8.	12300	33.0	38.33	468.67	1.1	69	97.93	Seawater (without cooling)
9.	9900	35	39.17	538.3	1.8	73	41.03	Dairy effluent (with cooling)
10.	7400	34.9	38.28	934.9	2.4	75	69.88	Dairy effluent (with cooling)
11.	11200	35.01	41.56	594.99	1.2	70	82.74	Dairy effluent (without cooling)
12.	7400	35.32	42.57	909	1.1	74	91.91	Dairy effluent (without cooling)

Table 1 is the tabulated data obtained by Vinoth et al., (2007). The table shown that the rate of evaporation will increase with the increase of the temperature differences.

Passive Solar Still

Passive solar still system is a system that fully utilizes the energy from the sun, whereas the active solid still system is a system that using other equipment to produce heat. Tiwari et al., (2008) stated that the thermal performance of solar still is affected by several design parameters like water depth, thickness of glass cover, insulation thickness, condensing cover material, and also affected by climate change. However, Kumar et al., (1998) stated that the performance of solar distillation system is governed by the rate of evaporation from the water surface in the basin. This depends on water and glass cover temperature differences.

Therefore, this research will focus on the effect of using that combination in the solar still system toward the evaporation rate. Table below shows the previous research on active and passive solar still that using several type of outsource to enhance the productivity of potable water from solar still distillation system.

Table 2: Types of Outsource and Maximum Water Production

Authors	Study area and date	Enhancement method	Maximum water production (L/m²)
F. F. Tabrizi and A. Z. Sharak [5].	Iran, 2010	Sandy heat reservoir was added to a solar still basin.	3.00 L/m² During 16 hours
V. Velmurugan et al [6].	India, 2008	Fin, sand, sponges, pebbles and black rubber were added in the basin of single slope solar still.	2.77L/m² During 10 hours
A. Ahsan et al [7].	Malaysia, 2014	Solar still using black painted Perspex sheet basin and transparent Polythene film cover	1.55L/m² During 12 hours
G.N. Tiwari et al [8].	2009, India	Parametric study of an active solar still integrated with a flat plate collector (FPC)	2.85L/m² During 24 hours
Gajendra Singh et al [9].	2011, India	Experimental study of an active solar still integrated with 2 solar flat plate collectors (FPC)	7.54L/2m² During 24 hours
Saettone. E [10].	2012, Peru	Active solar still using parabolic-trough concentrator (PTC)	6.36L/m² During 24 hours

CHAPTER 3

METHODOLOGY

Project Flow

The research methodology is planned and scheduled properly to ensure all the plan of activities performed efficiently. Basically, the process flow started with review of the past research called the literature review and followed by the experimental process.

Basically, this research is divided into two, which is :

- Preliminary Research (FYP 1)
  - Literature review – past research
  - Studying and understanding the concept of solar still
  - How to conduct the experimental activities at the next stage of methodology

- Secondary Research (FYP 2)
  - Fabrication of solar still system model
  - Data collection and analysis

In general, the research methodology flow is shown the chart below. The time planning is also shown in the Gantt chart below.

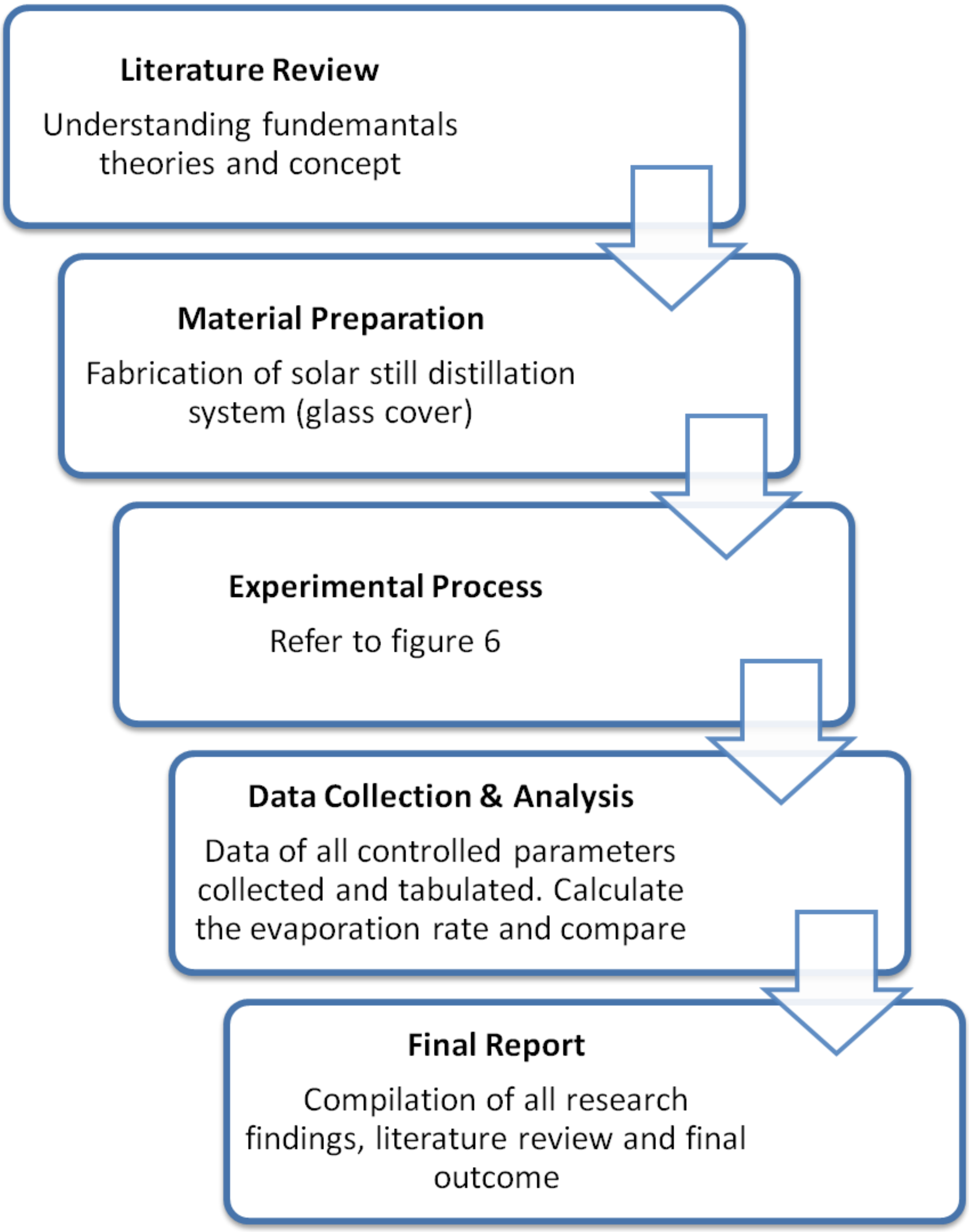


Figure 4: Flow Chart of the project research

Gantt Chart and Milestone

Table 3: FYP 1 Gantt Chart

No.	Detail/ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Selection of Project Topic	■	■												
2	Preliminary Research Work		■	■	■	■									
3	Submission of Extended Proposal						●								
4	Proposal Defence								■	■					
5	Project work continues										■	■	■		
6	Submission of Interim Draft Report													●	
7	Submission of Interim Report														●

● Suggested milestone
■ Process

Table 4: FYP 2 Gantt Chart

No.	Detail/ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Project Work Continues	■	■	■	■	■	■	■								
2	Submission of Progress Report							●								
3	Project Work Continues								■	■	■	■	■			
4	Pre-SEDEX										●					
5	Submission of Draft Final Report											●				
6	Submission of Dissertation (soft bound)												●			
7	Submission of Technical Paper												●			
8	Viva													●		
9	Submission of Project Dissertation (Hard Bound)															●

● Suggested milestone
■ Process

Experimental Methodology

There are 3 experiments will be conducted, which is:

a) Conventional solar still distillation system
b) Black painted basin solar still
c) Black soil solar still

Passive solar still system is a basic solar still system, which the system works, depends only on the solar radiation. In this research, author conduct 3 experiments involved the passive solar still, which the controlled parameters are the basin type.

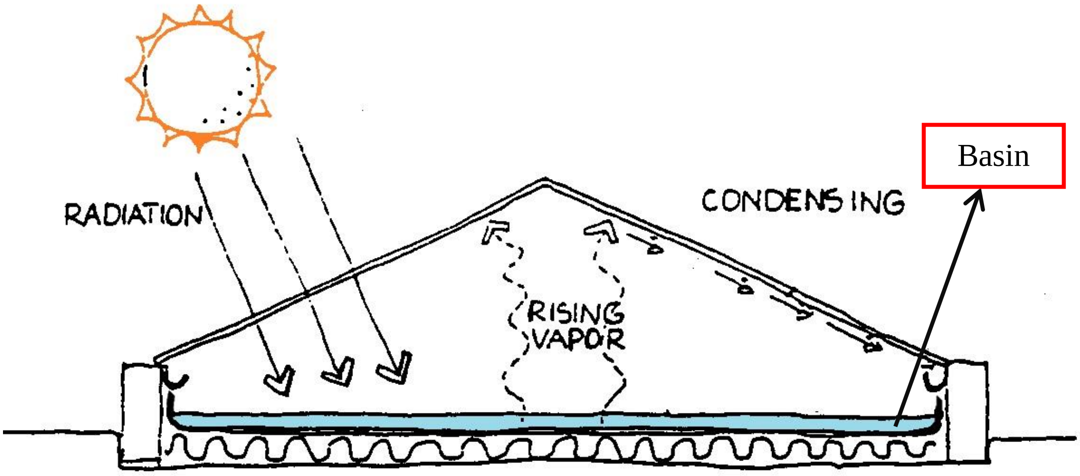


Figure 5: Passive Solar Still Distillation System

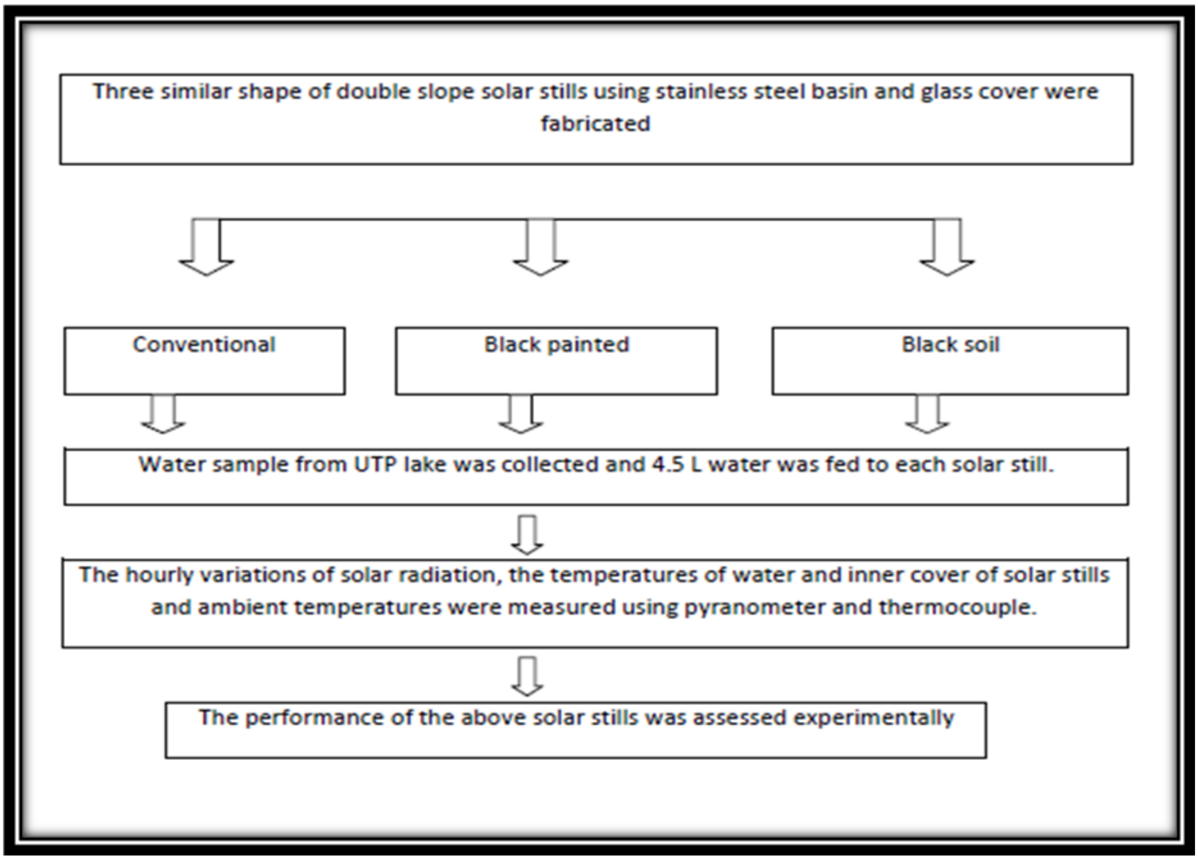
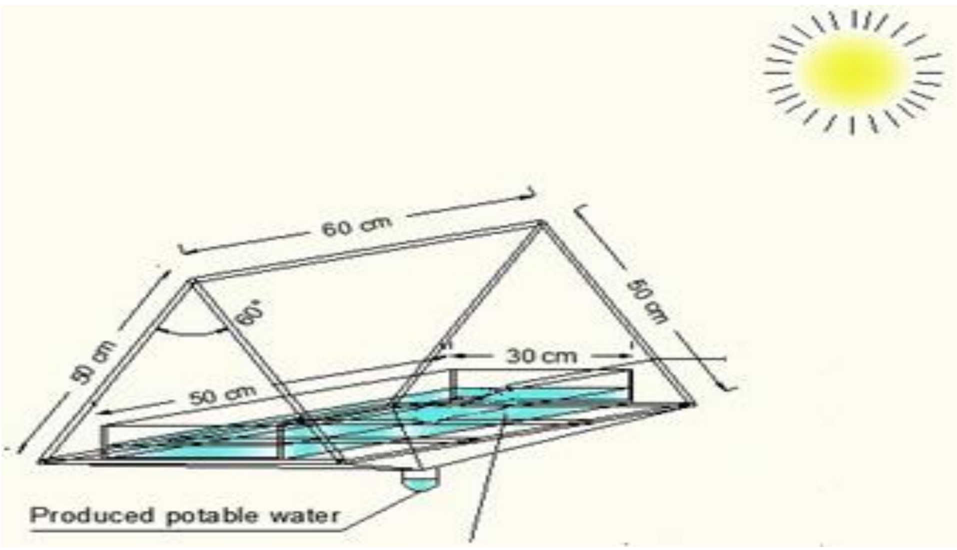


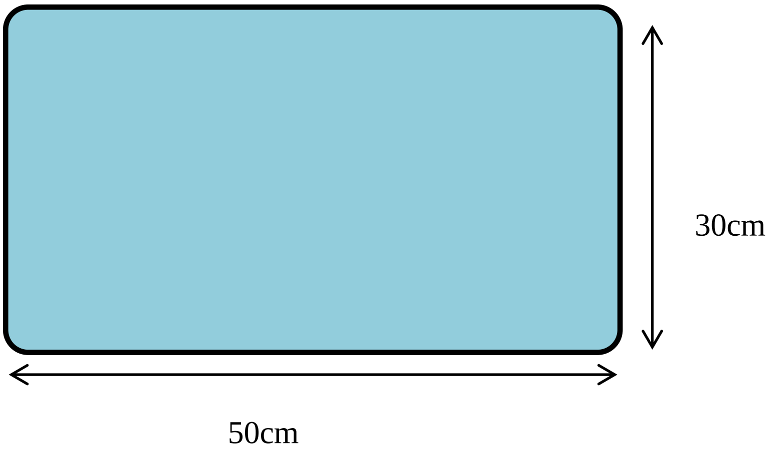
Figure 6: Experimental Methodology

<u>Material Preparation</u>

In order to conduct the experiment, the solar still system was fabricated precisely according to the correct dimension. The solar still system consists of:



Stainless Steel Basin



Cover – Glass

Figure 7: Fabrication of Solar Still System

The experiments conducted in the solar field testing facility where it is an open space and receive highest amount of solar radiation in UTP. The temperature of inner cover and the temperature of the water were measured using thermocouple.

Figure 8: Thermocouple

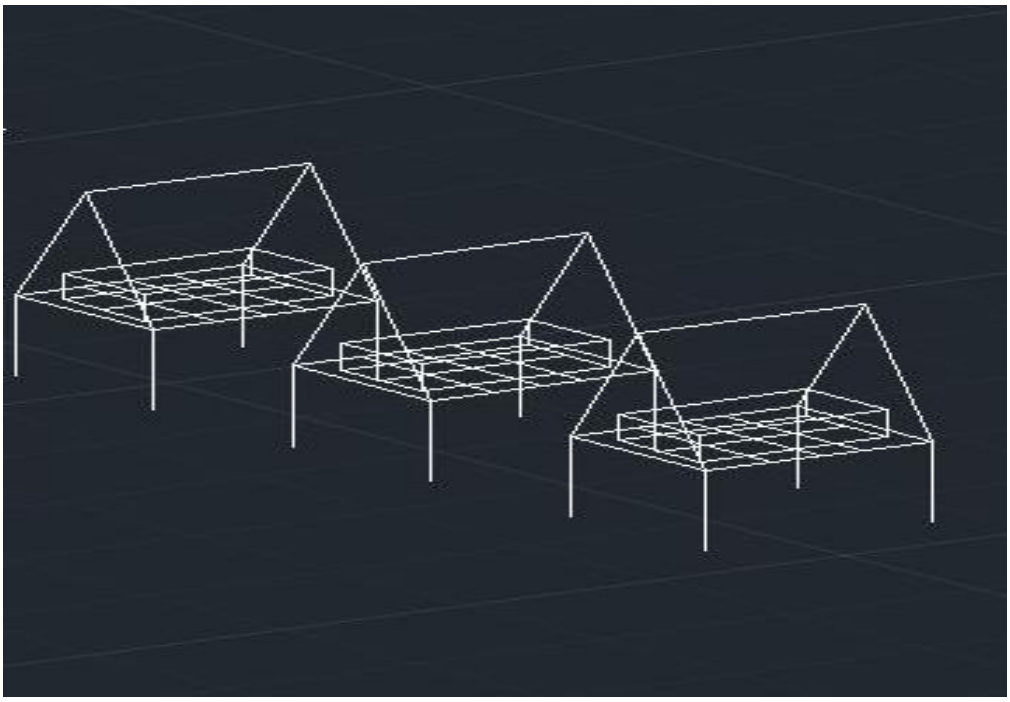


Figure 9: 2D Wireframe Drawing of the Arrangement of the Experiment

CHAPTER 4

RESULT AND DISCUSSION

The experiment was done on the 4 Aug 2015, at the solar field, UniversitiTeknologi PETRONAS, Tronoh, Perak. All the data obtained had been interpreted in the graph as per below.

Conventional Solar Still

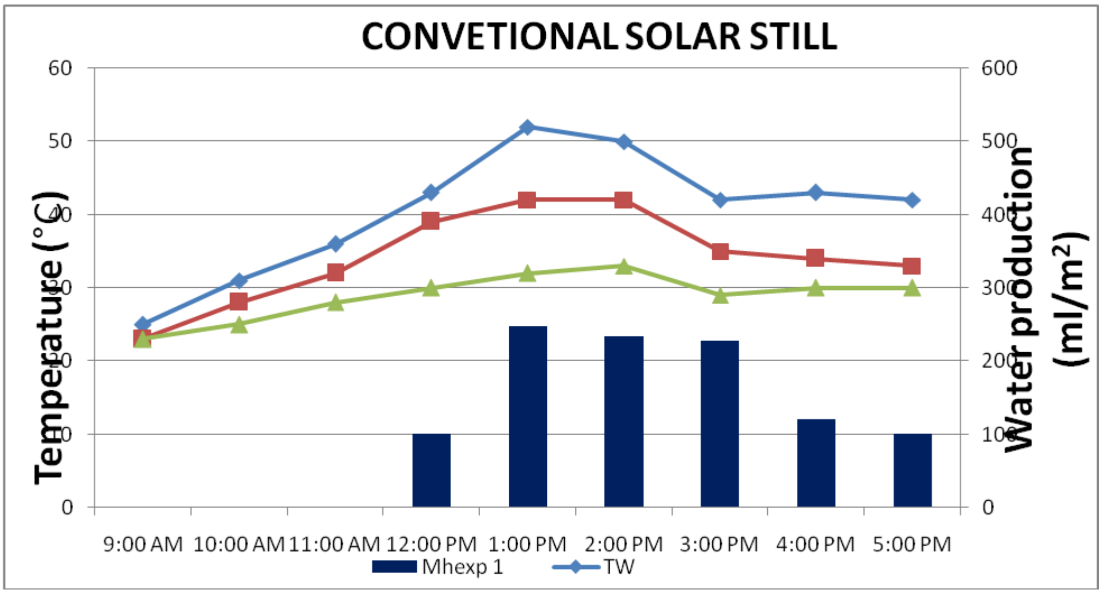


Figure 10: Hourly values of temperatures of water, inner cover of solar still and ambient temperature versus the hourly values of water production of conventional solar still on 4 Aug 2015 from 9 am to 5 pm

The graph contains the information of:

-Ambient Temperature (Ta)
-Inner Cover Temperature (Tic)
-Water Temperature (Tw)
-Water Production (Mhexp)

Based on Figure 10, the curve shows that the temperatures of water, inner cover, and ambient are directly proportional to the solar radiation intensity. Though, the production of the water also has the peak value at 1pm, 247ml/m^2 where the water, inner cover, and ambient temperature are highest.

<u>Solar Still with black soil in the basin</u>

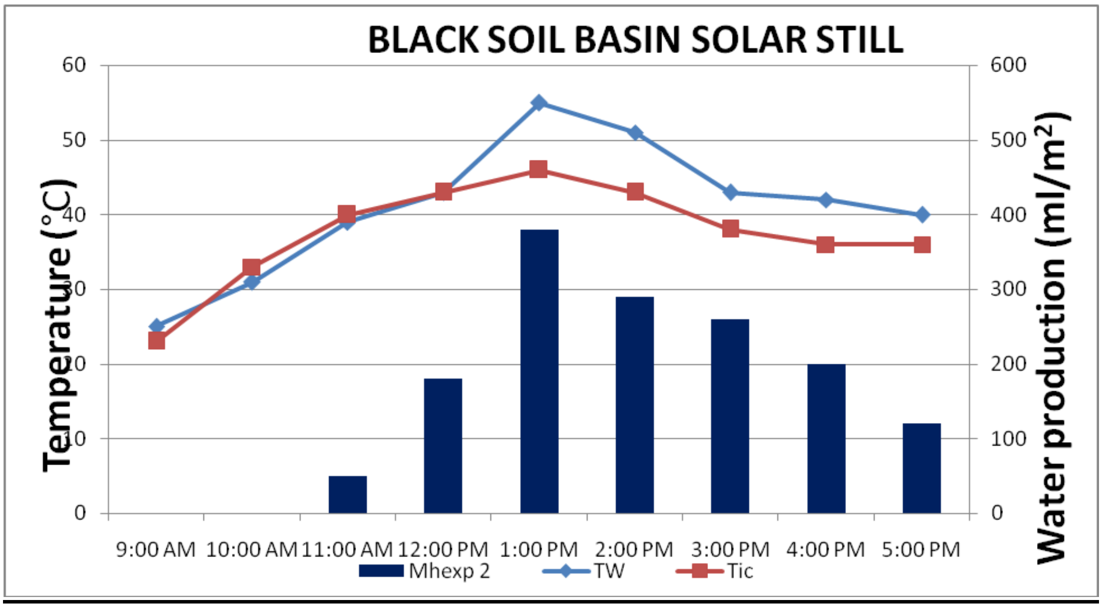


Figure 11: Hourly values of temperatures of water, inner cover of solar still and ambient temperature versus the hourly values of water production of solar still with black soil on 4 Aug 2015 from 9 am to 5 pm

The graph contains the information of:

-Inner Cover Temperature (Tic)
-Water Temperature (Tw)
-Water Production (Mhexp)

Based on the Figure 12, the curve also shows that the temperature of water and inner cover are also directly proportionate to the solar radiation intensity. The highest production of water is at 1pm, 380 ml/m^2.

Solar Still with Black Painted Basin

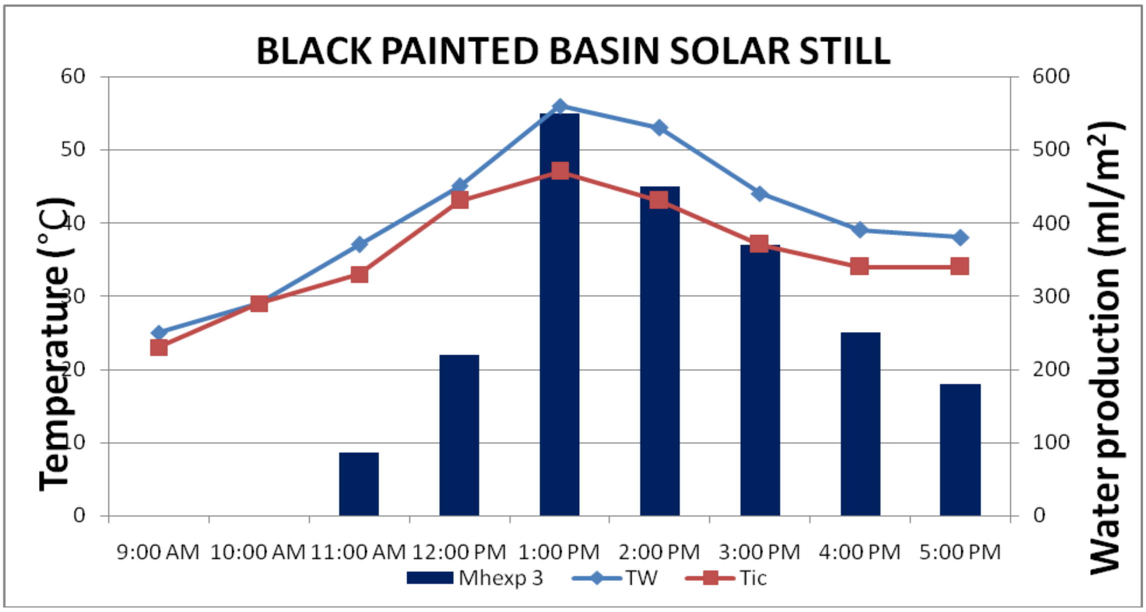


Figure 12:Hourly values of temperatures of water, inner cover of solar still and ambient temperature versus the hourly values of water production of solar still with black paint basin on 4Aug 2015 from 9 am to 5 pm

The graph contains the information of:

-Inner Cover Temperature (Tic)
-Water Temperature (Tw)
-Water Production (Mhexp)

Based on Figure 11, the curve also shows that the temperature of water and inner cover are also directly proportionate to the solar radiation intensity. The highest production of water is at 1pm, 550 ml/m^2.

Cumulative Water Production

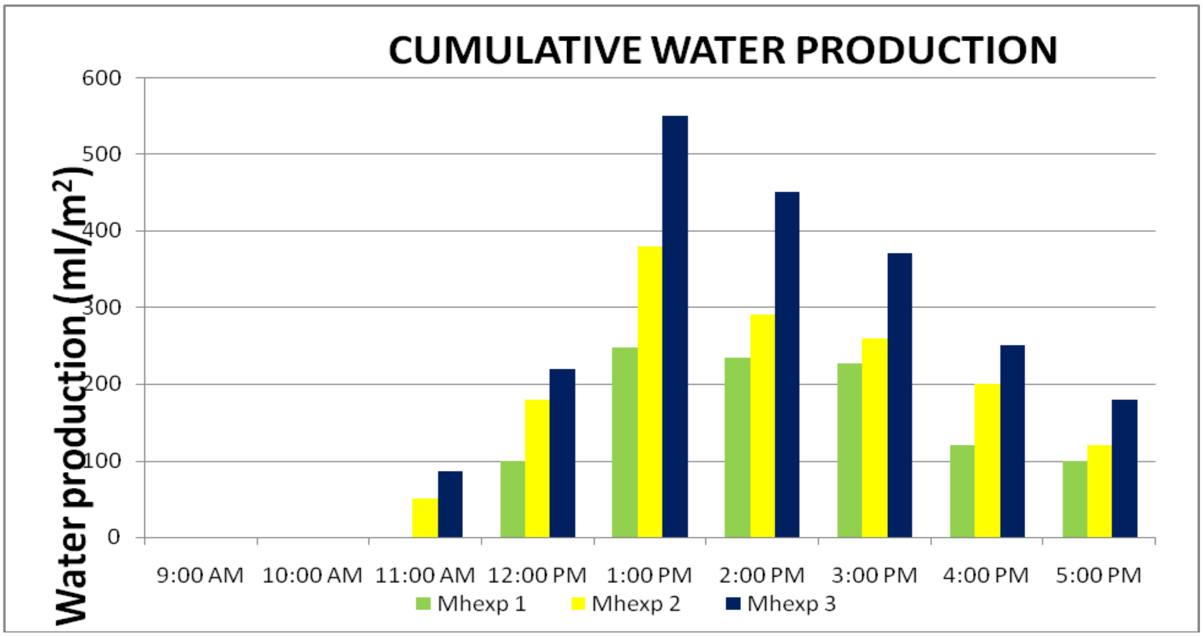


Figure 13: Hourly values of cumulative water production of conventional solar still, solar still with black painted basin and black soil basin solar still, respectively on 4 Aug 2015 from 9 am to 5 pm

The graph contains the information of:

-Water Production 1 (Mhexp1)
-Water Production 2 (Mhexp2)
-Water Production 3 (Mhexp3)

Based on the previous graph, we can see that Water Production 1 (Mhexp1) indicates the water production of conventional solar still. Same with water production 2 (Mhexp2), it indicates water production from solar still that have black painted basin. For water production 3 (Mhexp3), it is from solar still system with black soil at the basin.

Figure 14 shows that the cumulative production of the water from all solar still. Solar still system that have black soil produces the highest amount of potable water, compared to the other two, while conventional solar still system produce the lowest.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

This study is mainly to investigate the performance of solar still system using the black soil and black painted basin towards the conventional system. Throughout the experiment, it is expected that the performance of the system will increase, with the increase of the evaporation rate. The evaporation rate basically increases because of the increasing of the temperature difference between the water and the inner cover temperature because of the additional of the mentioned outsources.

Based on the result obtain, it is shows that the performance of solar still system with black paint basin is obviously increased up above 50% comparing to the conventional solar still. The water produced from the black painted system produce 2106 ml/m^2 while conventional solar still produce 1028 ml/m^2. With the highest value of solar radiation intensity, the ambient temperature is also highest at that particular time, and this will give a good impact towards temperature of the inner cover and the water temperature. When inner cover and water temperature increase, the water production will increase. In the black painted system, the heat was extra from the other two systems, where it comes from the sun, makes the evaporation rates increased and water production also got increased.

This project will solve a global issue – lack of potable freshwater. In a big scale, this enhanced system can produce high volume of freshwater at one time, and possibly can cater the needs of big scale of area especially remote and rural area where there is no source of freshwater. This system can be considered one of the most reliable option to obtain freshwater because of the production and maintenance cost is lowest compared to other option like water transportation by piping or tanker.

I would recommend that an experiment of a comparison between 2 types of active solar still system with different heat absorption materials at the basin for further research.

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