EVALUATION OF PERFORMANCE FOR BASIN WITH BLACK SOIL AND SEA SAND LAYER IN PRODUCING POTABLE WATER

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Dissertation submitted in partial fulfillment of the requirements for the Bachelor of Engineering (Hons) (Civil Engineering)

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Universiti Teknologi PETRONAS Bandar Seri Iskandar,31750 Tronoh, Perark Darul Ridzuan

CERTIFICATION OF APPROVAL

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A Project Dissertation submitted to
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the BACHELOR OF ENGINEERING
(Hons) (CIVIL ENGINEERING)

Approved by,

____

(DR.HJ.KHAMARUZAMAN B. WAN YUSOF)

UNIVERSITI TEKNOLOGI
PETRONAS TRONOH, PERAK
May 2014

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 acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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(NURAIZZAH BINTI MOHD AZEZS)

ABSTRACT

The rapid growth in industry has greatly increased the demand for fresh or clear water in Malaysia. Water is important and very essential in life. Inadequate of clear water supplied is a big issue that must be taken seriously. Therefore, water conservation must not be an option anymore. However, as the practical alternative, solar distillation can provide a solution for the areas where the solar energy is available. Solar distillation is the simple way for obtain drinking water or distilling water which sunlight as the main energy that used to power that process. Solar distillation is environmentally safe and uses solar radiation to evaporate lake water into potable water. The main objective of this project is to identify the best material for acting as the heat storage of the system in order to help to increase the evaporation rate in the solar still system for producing potable water. Thus, solar still farm can be built with economically solar still system installed. Method involved using three solar still with different materials used in the basins – with black soil, sea sand layer and conventional to compare the absorption or capture solar with water production. Water collected is then tested at the lab in order to ensure the water is safe to be drink. The present investigation showed the black soil basin has productivity up to 1953.33 ml/m^3/d which is much higher than conventional stainless steel basin, 893.33 ml/m^3/d and 1746.67 ml/m^3/d for sea sand layer basin. Solar still water production under Malaysia conditions has potential to grow as even during the cloudy weather, solar still can also produce high production.

ACKNOWLEDGEMENTS

First and foremost I would like to express my thanks to Allah s.w.t because of His love and strength that He has given to me to finish this report as my final year project report (FYP). I do thank for His blessings to my daily life, good healthy mind and good ideas.

This report is important to fulfill part of the programme criteria that is a requirement to fulfill the Bachelor Program in Civil Engineering at Universiti Teknologi Petronas(UTP).

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CHAPTER 1

INTRODUCTION

1.1 Background of study

Water is important and very essential in life. Inadequate of water supplied is a big issue that must be taken seriously. However, supplying drinkable water is one of the major problems in developing countries especially at the rural areas where the area are really hard to find a clear water sources. Thus, the availability of potable water must be implemented in order to solve the problem for the communities who lived in this remote region. In addition, dry seasons also may leads to the problem of getting clear water in daily life.

Solar still can provide a solution for the areas where the solar energy is available but water quality is not good or there is no water supply available. Solar energy which can be utilized in order to obtain drinkable water from salty or brackish water and also any fluids using the use of solar still to capture the evaporated water by condensing it. Solar still is the simple way for obtain drinking water or distilling water which sunlight as the main energy that used to power that process. In general, principle of the solar water distillation is the sun will heats the water and water will evaporated. As the water evaporates, water vapor is rises and condenses on the glass surface for collection. In addition, this process have removes the impurities such as salts and heavy metals. Microbiological of organisms also destroyed during this process.

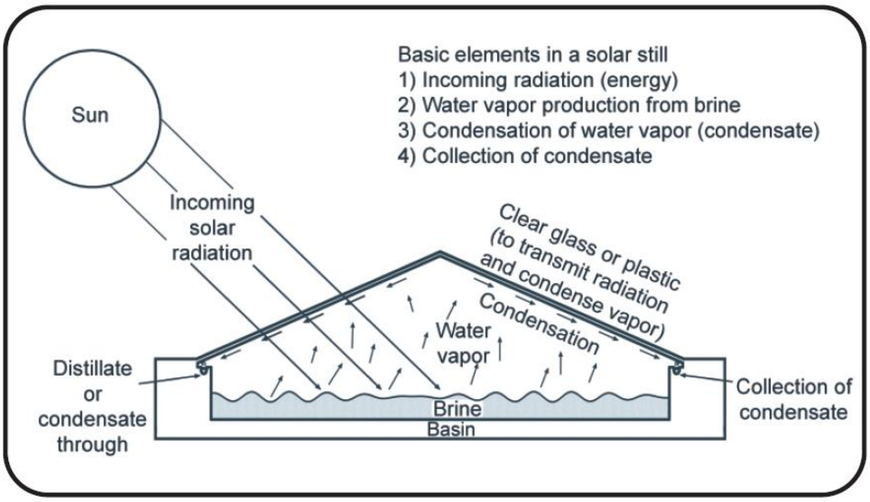


Figure 1. Solar Still System (concept)

Passive solar distillation is generally will provide low productivity. However, there are several factors that affecting the performance of the solar still such as solar intensity, ambient temperature, wind velocity, water-glass temperature difference, water surface area, absorber plate area, glass angle and depth of water. As we know, for the solar intensity, productivity of the solar still increases as the incident solar radiation increases. In addition, meteorological parameters such as solar intensity, ambient temperature, and wind velocity are uncontrolled parameters whereas the remaining parameters can be varied in order to enhance the productivity of the solar still.

In order to enhance the productivity of the solar still in producing maximum volume of the potable water, several modifications during experiment need to be made. For this study, the main variables are the materials use in the basins of the solar still where the water to be distilled is kept. Black soil and sea sand will be used in this study in order to find out the best materials that must be used for helping the basins to keep the heat for the solar still system in order to enhance the evaporation rate by using triangular polythene film cover. As we know, color is also having the role of absorbing or releasing the heat. Black color is good in absorbing and keeping heat especially during day time which solar intensity is high and available.

Other than that, particles arrangement of the soil and sand also played role in keeping the heat. Thus, this study will help us to prove the best materials need to be use in enhancing the productivity of the water produce. The best materials used at the basin can help to increase the rate of evaporation in the systems which also help to reduce energy lost to surrounding. However, in order to prove the theory is acceptable, several experiments were design and the result will be analyses.

1.2 Problem Statements

As the fresh water production is diminishing globally, alternatives to increase the productivity is important. Other than that, in rural area, supplying clear water is the critical problem that we need to face. Water is important to human being. Thus, solar still can help to solve this problem in order to purifying the water and supply clear water. During dry season especially long term of dry seasons, water interruption will occurred. In order to avoid such problem, sun energy that available can be used as one of the solutions to the problem.

1.3 Objectives

This research is actually giving an overview on the impact of the materials and method used for solar still in order producing maximum volume of potable water collected for the project that can provide community services such as solar still farm which can help to produce potable water during dry season or at the rural area.

Below are the main of the objectives of this project:

- To identify which material is the best heat storage in order to help to increase the evaporation rate in the solar still system (sea sand, black soil or conventional basin) in order to produce potable water.
- To determine the amount of potable water production of the solar still per square meter in a day

1.4 Scope of Study

This study will be focused on the solar still system design and fabrication in order to produce maximum volume of potable water collected. Parameters that affecting the solar still productivity and potable water collected will be considered in order to vary the method used in achieving the objectives stated. Several modifications will be done to get the results on volume of water collected using different materials and method.

Generally, experiment is carrying out by using black sand, sea sand and conventional basin in order to compare the performance of the materials use in the basins term of volume potable water collected. This experiment is helping us to compare the ability of those materials in order to keep and absorb heat which can help for enhancing the rate of evaporation. Above all, the relationship between water temperature and water productivity is the most critical aspect for this study. Thus, method and materials used for this system must be select intelligently in order to ensure more heat can be absorb for the evaporation process to occurs and more potable water can be produce.

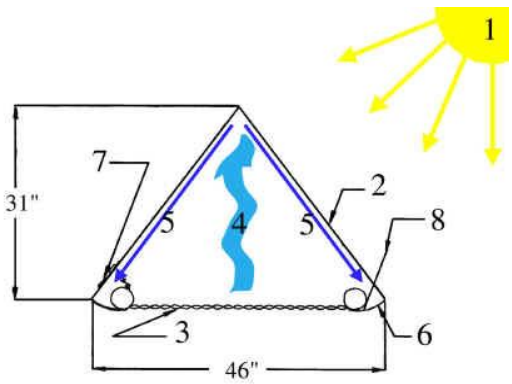


Figure 2. Example of Solar Still Design

1.5 Relevancy and feasibility

This project can be a reference for further application and improvement that will be done on solar still project because it provides more understanding on how can the parameters of enhancing the potable water collected can be varies.

Solar still farm can be form with cheaper and more efficient solar still system which can also help the communities in order to obtain drinkable water.

CHAPTER 2

LITERATURE REVIEW

2.1 Solar still system

The solar still system will not only save the money and time, it is also an environmentally friendly which can help the producing of fresh water. Badran (2007) stated that solar distillation a methods for water distillation which sunlight is one of several forms of heat energy that can be used to power the process which sunlight also has the advantages of zero fuel cost. In addition, solar energy is an abundant, never lasting and it is pollution free (Kaushal and Varun, 2010). Since sunlight is come from the natural source, the statements gave is totally relevant. For the passive solar still, there is no combustion or heater needed in order to ensure the available of heat for the evaporation process occurred where sun energy is always available during day time. Thus, we can save the cost and protect our environment from air pollution problem.

Mehta et al., 2011 was stated that solar water distillation is not a new process, but it has not received the attention that it deserves. As we know, solar distillations enquire low cost for the implementation because solar still system needs no complicated machinery or electrical components. Fabrication of the solar still is simple and easy. Besides, 3.8x1024 joules of solar radiation is absorbed by earth and atmosphere is 1017 watt and the total demand is 1013 watts which showed that sun gives us 1000 times more power than we need (Mehta et al., 2011).

2.2 Study of the parameters that affecting the solar still productivity

Generally, solar still system is categorized into two systems which are the passive solar still and the active solar still. Passive solar still is the system which are using 100 % of sunlight energy or using the nature heat whereas active solar still is the system that used other equipment or tools in order to produce heat such as heater, help of electrical component and also machinery components. For this study, passive solar still is more preferable as the advantages of the passive solar still have been discussed earlier (above). As mentioned earlier, the factors that affecting performance of the solar still are solar intensity, ambient temperature, wind velocity, water-glass temperature difference, water surface area, absorber plate area, glass angle and also the depth of water where the meteorological parameters such as solar intensity, ambient temperature, and wind velocity are uncontrolled parameters whereas the remaining parameters can be varied in order to enhance the productivity of the solar still. The research and development done so far has yielded additional useful information on the materials of solar still. The still cover, being one of the most important components, should have its constituent material carefully vetted. Among the possible choices are glass and plastic (Muftah et al., 2014).

In my opinion, glass is a good conductor which can help to increase the evaporation process but can be consider as costly materials. Stated from the previous study on the effect of using different designs of solar stills on water distillation, the glass cover allows the solar radiation(shortwave) to pass into the still (Al-Hayeka & Badran, 2004). For plastic, even though it is not a good conductor but as long as the plastic that we are going to use are transparent enough, this will help the evaporation to take place where the solar radiation can pass into the still. As addition, plastic is cheaper than the glass. Heat transfer between the water and the glass cover mainly depends upon their temperature difference which acts as a driving (Jamal & Siddiqui, 2012).

Thus, the depth of water is important in order to consider the modification that need to be done. From the previous study, researchers have investigated different types of solar stills including single basin stills, multiple-effect stills, wick solar stills, and hybrid designs, all in the interest of improving its efficiency (Muftah et al., 2014). As we know, larger surface area will help evaporation occur efficiently. Thus with low depth of water and larger surface area of the still basins probably will help to enhancing the productivity of the potable water. From a journal title, Optimization of Orientation for Higher Yield of Solar Still for a Given Location, it is mentioned that a transparent cover with an inclination angle of local latitude can fully receive solar radiation which leads to increased productivity (Singh et al., 1995).

Furthermore, the material used for coating the basin also influences the rate of absorbing solar radiation, as well as using materials which act as storage mediums of heat, are advantageous to increase output (Murugavel KK et al., 2010). From Experimental Study of a Solar Still with Sponge cubes in Basin, reported that the distillate production is increased much higher up to 273% with black sponge cubes compared to the still without sponges cubes. Bassam et al. made use of placing yellow and black sponge cubes, black coal and black steel in a basin to test for the increase of free surface area of water and evaporation rate. It is noted that the yellow color of sponge cubes reflects some of the incident radiation onto the walls of the still and result in heat loss. Although initially the results reported that yellow sponge cubes produce slightly higher results than black sponge cubes. However, it was reasoned that theoretically black sponge should absorb more heat and may be due to covering of holes when spraying black paint on the sponge cubes. It was recommended to use naturally black sponge cubes for best effect. The report states that black sponge cubes with sponge-to-water volume ratio of 20% are recommended for a basin solar still, although the optimized size of a cube still differs with water depth in the basin. In this study, we will see the comparison of the potable water produce between using different materials use in the basins in order to help the increasing of heat trap to the water which can help to enhance the rate of the evaporation of solar still system.

Other than that, wind speed was noted to be highest when obtaining maximum amount of distillate as well. However, there are some reports which contradict another. Voropoulos et al., states that low ambient temperature aids in improving productivity, while Badran (2007) claim that increased wind speeds aid in productivity. In the other hands, Nafey et al. and Velmurugan et al. stated that with lower wind speeds, higher distillation output is produced. The reason for the controversy may be due to the greater temperature difference between the water and glass cover when a higher velocity wind or lower ambient temperature passes through the solar still, as well as a greater heat loss to the surroundings in the process. Increase in temperature difference has a positive effect but heat loss to surroundings does not.

Figure 3. Examples of solar still system using differents type of shape

CHAPTER 3

METHODOLOGY

3.1 Research Methodology

The research methodology was scheduled and planned scientifically to ensure the whole activities performed efficiently. The process flow started with the literature review and followed by the experimental process.

PRELIMINARY RESEARCH:

- ❖ Literature reviews- past research
- ❖ Studying and understanding the basic knowledge of solar still.
- ❖ Obtaining basic idea on experimental activities will be done at the next phase of methodology (secondary research)

SECONDARY RESEARCH:

- ❖ Fabrication of the solar still system model
- ❖ Data collection and analysis

In general, the research methodology flow chart is shown in the figure 4 and the gantt chart for the whole study is show as in the Table 1 and Table 2

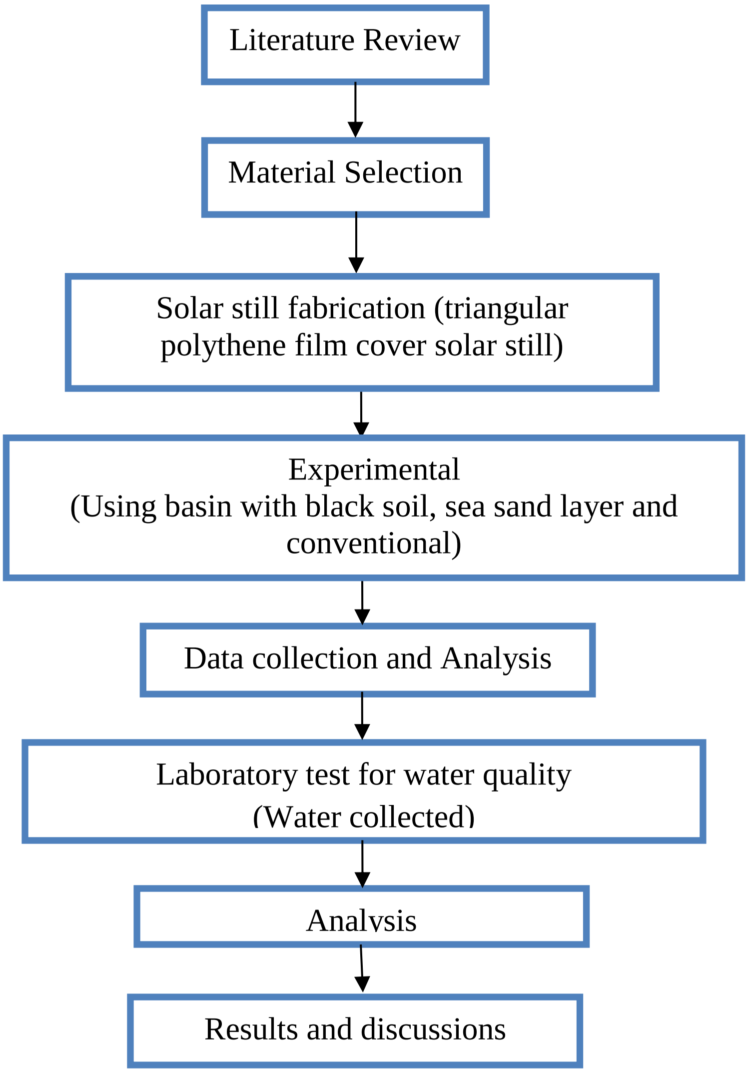


Figure 4. Flow chart of the project

3.2 Project Activities

These experimental processes separate into seven main stages as below:

i. <u>Material selection.</u>

In fabricating solar still system, several parts need to be construct and each of the part have their own role in order to produce the solar still. Thus, choosing materials that need to be use during the fabrication process is important.

- **Still basin:** part where the water to be distilled is kept. The material use must have high absorptivity and less transitivity.
- **Side walls:** will provide rigidness to the still. The material use must have low thermal conductivity and rigid.
- **Top cover:** where the irradiation will occurs. The material must be transparent and good conductor.
- **Channel:** passage which fetch out the pure water. The material use must be impermeable.

Other than selecting the materials for the solar still itself, materials used at the basin also need to be selecting which will affect the rate of evaporation of the system.

Materials use:

- Black soil – have the ability to absorb heat faster and release the heat faster
- Sea sand – have the ability to keep heat more longer but lower rate of absorbing heat.

ii. First fabrication of solar still with 60^{o} tilt angle and $0.15m^2$ base area - using polythene film cover.

Three solar still system will be fabricate with the same dimensions, same number of basin still, same materials used for every part except for the materials use in the basins. One of the basin used black soil, next is used sea sand and another one is conventional which act as the control of the experiment.

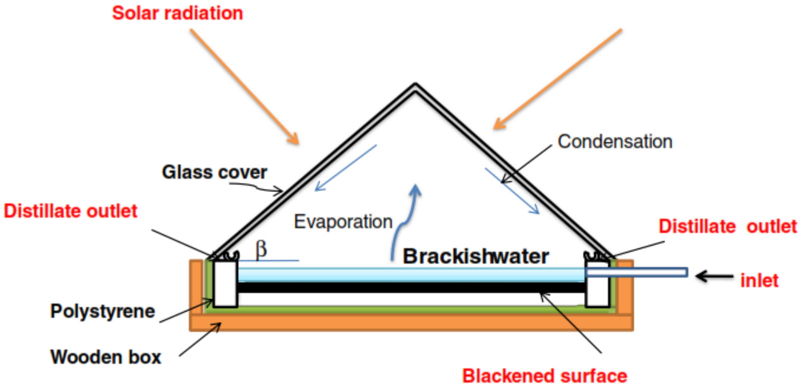


Figure 5. Example of fabrication solar still system

iii. <u>Data collection</u>

There are several parameters need to be record during the experiment. There are:

- Temperature of water in basin of solar still
- Temperature of inner cover of solar still
- Ambient temperature
- Temperature of humidity in solar still
- Temperature of outer cover of solar still
- Hourly water production of solar still
- Daily water production of solar still

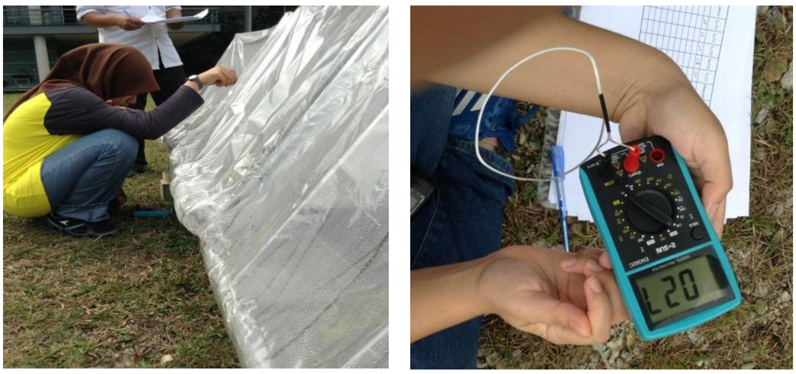


Figure 6. Multimeter device used in experiment

iv. Laboratory test – water quality test for water collected

In order to ensure the water producing by the solar still are drinkable, several parameters need to be test. There are:

- pH
- Total dissolved solids (mg/l)
- Nitrate(mg/l)
- Sulfate(mg/l)
- Iron(mg/l)
- Turbidity(mg/l)
- Color (Hazen unit)

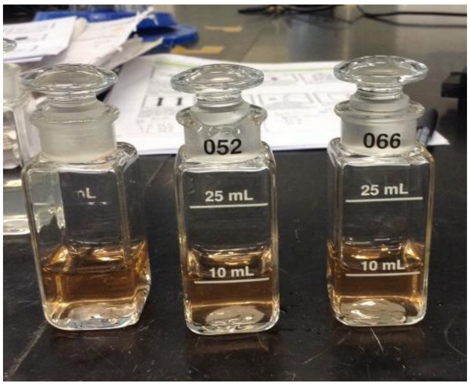


Figure 7. Example of Water Quality test

v. Analysis

Results from the laboratory test are comparing with WHO standards drinking water quality parameters.

Figure 8. Example of water collected

vi. Result and discussion

3.3 Materials & Equipment

- ❖ Polythene film
- ❖ PVC pipes
- ❖ Black soil
- ❖ Sea sand
- ❖ Stainless steel basin
- ❖ Multimeter - Ambient temperature, Polythene cover, Water in basin, etc
- ❖ Measuring cylinder
- ❖ Water bottles (Water storage)
- ❖ pH meter
- ❖ Turbidimeter

Figure 9. Measuring cylinder

Figure 10. Turbidimeter

3.4 Gantt Chart and Key milestone

	ACTIVITY	WEEK													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Selection of Project Topic														
2	Supervisor Introduction														
3	Preliminary Research Work														
4	Submission of Extended Proposal						●								
5	Proposal Defence									●					
6	Materials Selection											●			
7	Ordering of Materials														
8	Project work continues														
9	Submission of Interim Draft Report													●	
10	Submission of Interim Report														●
11	Project work continues														

Table 1. FYP 1 Gantt Chart

	ACTIVITY	WEEK														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Project Work Continues															
2	Design and Modeling						●									
3	Experimental															
4	Submission of Progress Report							●								
5	Experiment Continues									●						
6	Data and result analysis															
7	Pre-SEDEX										●					
8	Submission of Draft Final Report															
9	Submission of Dissertation (soft bound)													●		
10	Submission of Technical Paper													●		
11	Viva														●	
12	Submission of Dissertation (hardbound)															●

Table 2. FYP 2 Gantt Chart

Duration

Milestone

CHAPTER 4

RESULTS AND DISCUSSION

The results for the three basins experiment are obtained after 3 days period of experiment. Experiment was done on 18th, 19th and 20th of July. The results are presented as follows:

4.1 Ambient Temperature (°C) for 3 days Experiments

Time/Date	18th July 2014	19th July 2014	20th July 2014
9.00 am	28	25	26
10.00 am	30	30	29
11.00 am	30	33	31
12.00 pm	32	33	34
1.00 pm	30	35	33
2.00 pm	33	36	32
3.00 pm	35	37	31
4.00 pm	32	34	33
5.00 pm	32	32	31
6.00 pm	31	33	31

Table 3. Data for Ambient Temperature

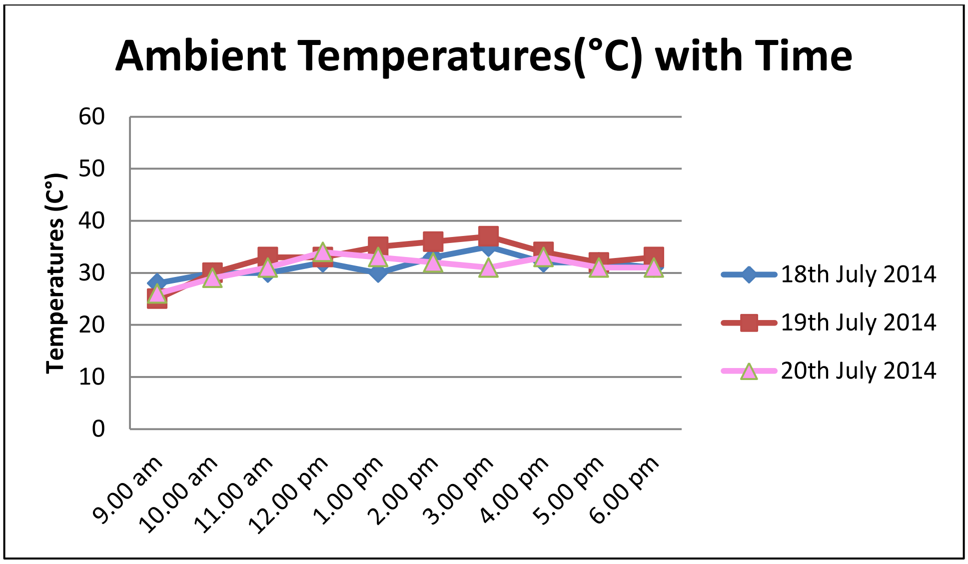


Figure 11. Graph Ambient Temperature (°C) vs Time

4.2 Results for Conventional Basin (Control)

Time	T_a	T_{oc}	$T_{humidity}$	T_{ic}	T_w	T_b	W_{hexp} (ml)	W_{dexp} (cumulative) (ml)	W_{hexp} (ml/m²)	W_{dexp} (cumulative) (ml/m²)
9.00 am	28	28	30	30	28	28	0	0	0.00	0.00
10.00 am	30	31	34	32	35	35	0	0	0.00	0.00
11.00 am	30	34	37	36	40	41	0	0	0.00	0.00
12.00 pm	32	35	42	40	45	45	27	27	180.00	180.00
1.00 pm	30	31	36	36	44	44	15	42	100.00	280.00
2.00 pm	33	35	41	40	46	46	21	63	140.00	420.00
3.00 pm	35	36	41	40	47	47	15	78	100.00	520.00
4.00 pm	32	35	39	38	46	46	21	99	140.00	660.00
5.00 pm	32	28	37	38	45	45	23	122	153.33	813.33
6.00 pm	31	33	37	35	43	43	3	125	20.00	833.33

Table 4. Data for 18th July (conventional)

Time	T_a	T_{oc}	$T_{humidity}$	T_{ic}	T_w	T_b	W_{hexp} (ml)	W_{dexp} (cumulative) (ml)	W_{hexp} (ml/m²)	W_{dexp} (cumulative) (ml/m²)
9.00 am	25	28	31	31	29	29	0	0	0.00	0.00
10.00 am	30	31	35	34	35	35	6	6	40.00	40.00
11.00 am	33	33	36	36	42	42	3	9	20.00	60.00
12.00 pm	33	30	40	39	46	46	9	18	60.00	120.00
1.00 pm	35	30	40	40	48	48	11	29	73.33	193.33
2.00 pm	36	31	40	40	51	51	12	41	80.00	273.33
3.00 pm	37	38	42	42	50	50	14	55	93.33	366.67
4.00 pm	34	37	41	40	49	49	30	85	200.00	566.67
5.00 pm	32	34	37	35	44	44	9	94	60.00	626.67
6.00 pm	33	34	38	36	42	42	12	106	80.00	706.67

Table 5. Data for 19th July (conventional)

Time	T_a	T_{oc}	$T_{humidity}$	T_{ic}	T_w	T_b	W_{hexp} (ml)	W_{dexp} (cumulative) (ml)	W_{hexp} (ml/m²)	W_{dexp} (cumulative) (ml/m²)
9.00 am	26	25	26	26	26	26	0	0	0.00	0.00
10.00 am	29	24	32	30	34	34	12	12	80.00	80.00
11.00 am	31	34	39	36	44	44	5	17	33.33	113.33
12.00 pm	34	33	39	36	46	46	11	28	73.33	186.67
1.00 pm	33	34	42	38	48	48	20	48	133.33	320.00
2.00 pm	32	31	42	38	49	49	20	68	133.33	453.33
3.00 pm	31	29	38	39	48	48	10	78	66.67	520.00
4.00 pm	33	28	39	37	46	46	20	98	133.33	653.33
5.00 pm	31	34	37	36	42	42	26	124	173.33	826.67
6.00 pm	31	32	34	34	40	40	10	134	66.67	893.33

Table 6. Data for 20th July (conventional)

Where,

Tw = Temperature of water in basin of solar still

Tic = Temperature of inner cover of solar still

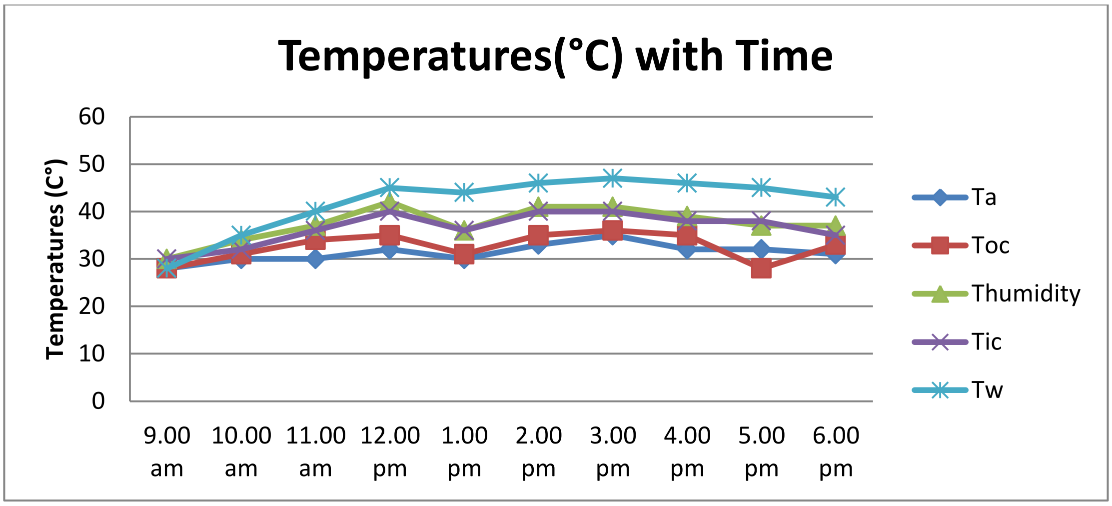
Ta = Ambient temperature

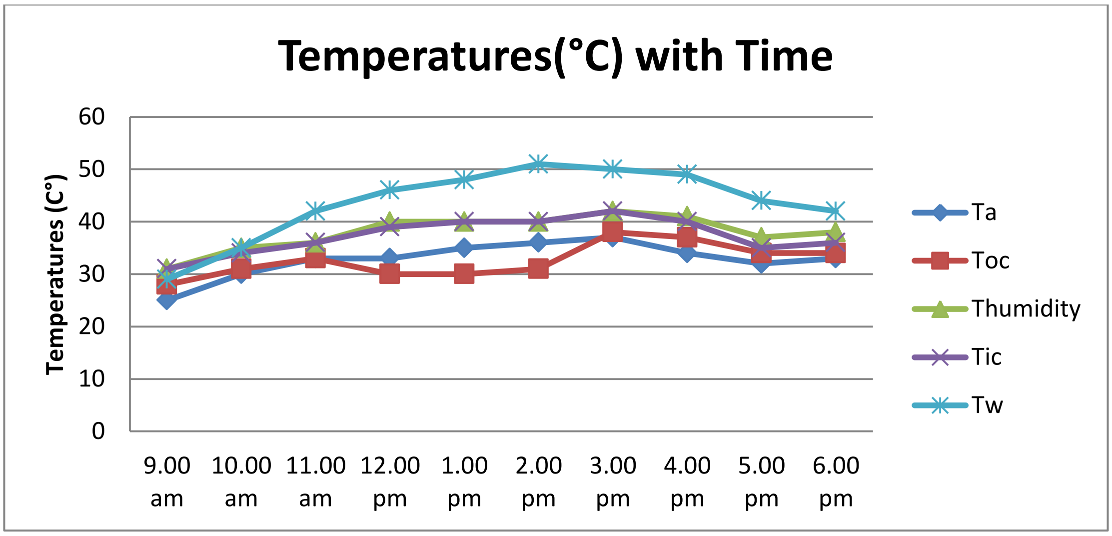
Thumidit = Temperature of humidity in solar still

Toc = Temperature of outer cover of solar still

Whexp = Hourly water production of solar still

Wdexp = Daily water production of solar still





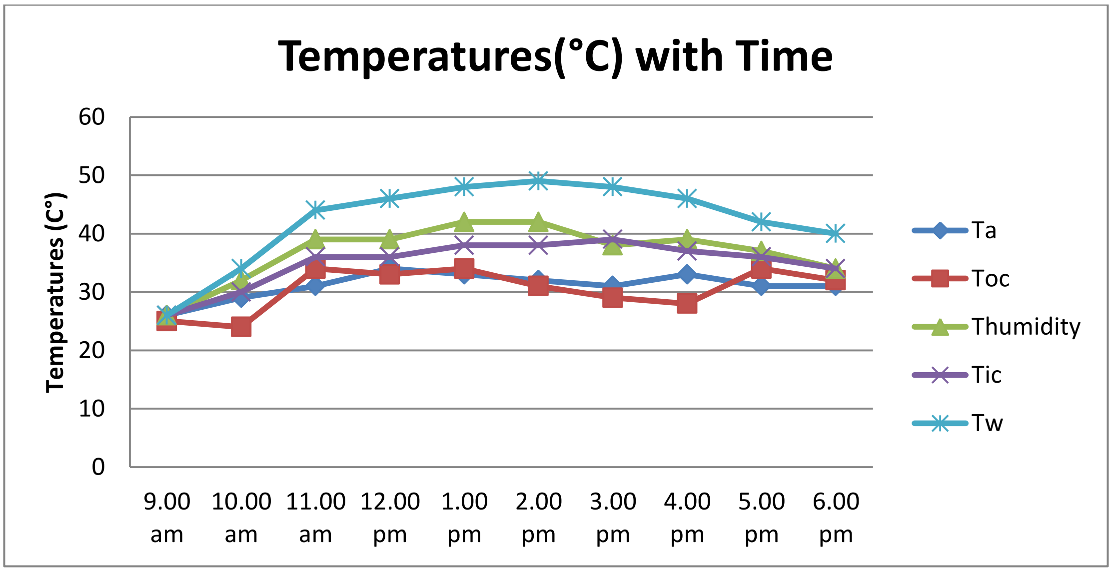


Figure 12. Graphs Temperature (°C) with Time (18th,19th,and20th July) –conventional-

4.3 Results for Black Soil Basin

Time	T_a	T_{oc}	$T_{humidity}$	T_{ic}	T_w	T_b	W_{hexp} (ml)	W_{dexp} (cumulative) (ml)	W_{hexp} (ml/m²)	W_{dexp} (cumulative) (ml/m²)
9.00 am	28	25	29	29	30	31	0	0	0.00	0.00
10.00 am	30	26	34	33	37	37	32	32	213.33	213.33
11.00 am	30	36	37	35	42	43	26	58	173.33	386.67
12.00 pm	32	31	38	38	46	47	43	101	286.67	673.33
1.00 pm	30	31	38	37	46	47	31	132	206.67	880.00
2.00 pm	33	30	39	39	47	47	34	166	226.67	1106.67
3.00 pm	35	32	39	39	47	48	36	202	240.00	1346.67
4.00 pm	32	29	39	37	47	48	35	237	233.33	1580.00
5.00 pm	32	28	38	35	45	45	46	283	306.67	1886.67
6.00 pm	31	33	35	35	43	43	10	293	66.67	1953.33

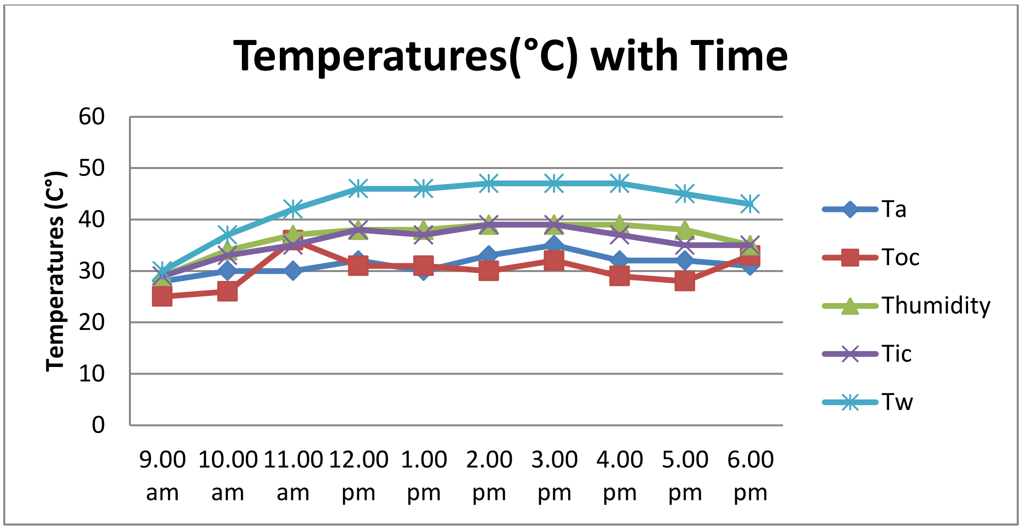
Table 7. Data for 18th July (black soil)

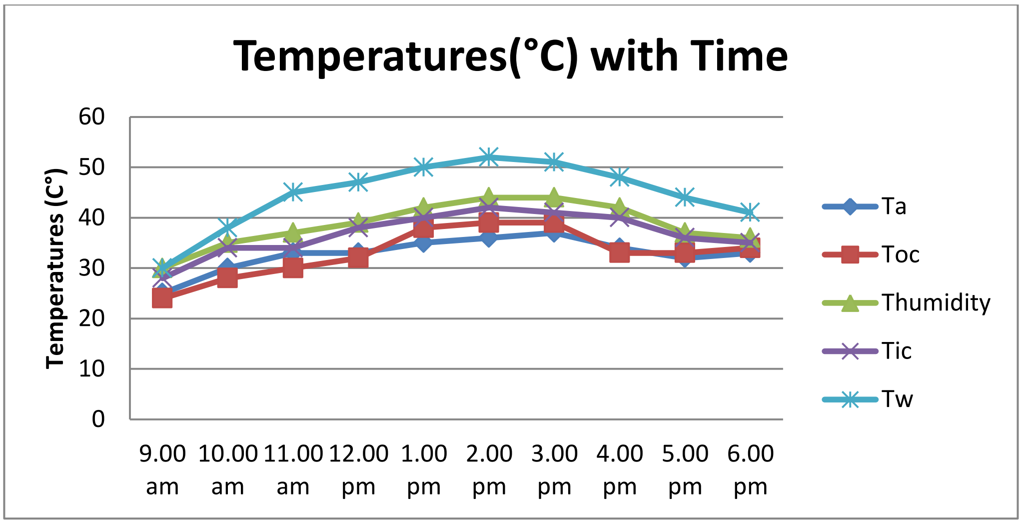
Time	T_a	T_{oc}	$T_{humidity}$	T_{ic}	T_w	T_b	W_{hexp} (ml)	W_{dexp} (cumulative) (ml)	W_{hexp} (ml/m²)	W_{dexp} (cumulative) (ml/m²)
9.00 am	25	24	30	28	30	30	0	0	0.00	0.00
10.00 am	30	28	35	34	38	38	9	9	60.00	60.00
11.00 am	33	30	37	34	45	45	13	22	86.67	146.67
12.00 pm	33	32	39	38	47	47	34	56	226.67	373.33
1.00 pm	35	38	42	40	50	50	44	100	293.33	666.67
2.00 pm	36	39	44	42	52	52	42	142	280.00	946.67
3.00 pm	37	39	44	41	51	51	42	184	280.00	1226.67
4.00 pm	34	33	42	40	48	48	42	226	280.00	1506.67
5.00 pm	32	33	37	36	44	44	36	262	240.00	1746.67
6.00 pm	33	34	36	35	41	42	17	279	113.33	1860.00

Table 8. Data for 19th July (black soil)

Time	T_a	T_{oc}	$T_{humidity}$	T_{ic}	T_w	T_b	W_{hexp} (ml)	W_{dexp} (cumulative) (ml)	W_{hexp} (ml/m²)	W_{dexp} (cumulative) (ml/m²)
9.00 am	26	25	26	26	28	28	0	0	0.00	0.00
10.00 am	29	30	34	33	36	36	16	16	106.67	106.67
11.00 am	31	30	40	38	46	46	11	27	73.33	180.00
12.00 pm	34	27	39	36	48	48	32	59	213.33	393.33
1.00 pm	33	31	41	38	49	49	39	98	260.00	653.33
2.00 pm	32	30	41	39	50	50	47	145	313.33	966.67
3.00 pm	31	30	39	39	48	48	40	185	266.67	1233.33
4.00 pm	33	35	40	39	47	47	30	215	200.00	1433.33
5.00 pm	31	34	36	34	42	42	50	265	333.33	1766.67
6.00 pm	31	32	35	33	40	40	10	275	66.67	1833.33

Table 9. Data for 20th July (black soil)





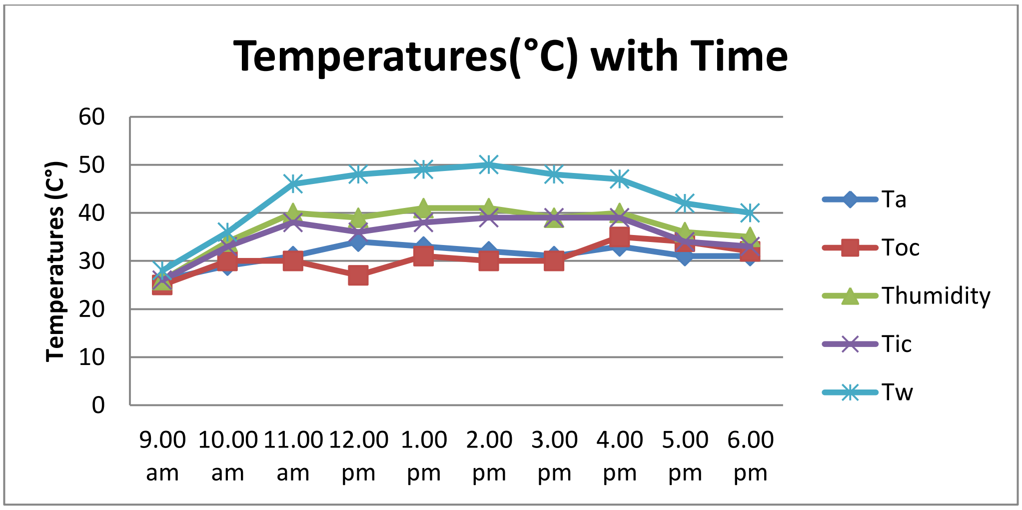


Figure 13. Graphs Temperature (°C) with Time

(18th,19th,and20th July) –black soil-

4.4 Results for Sea Sand Basin

Time	T_a	T_{oc}	$T_{humidity}$	T_{ic}	T_w	T_b	W_{hexp} (ml)	W_{dexp} (cumulative) (ml)	W_{hexp} (ml/m²)	W_{dexp} (cumulative) (ml/m²)
9.00 am	28	25	28	28	29	29	0	0	0.00	0.00
10.00 am	30	27	33	32	36	36	0	0	0.00	0.00
11.00 am	30	29	37	35	42	42	17	17	113.33	113.33
12.00 pm	32	29	38	37	46	46	29	46	193.33	306.67
1.00 pm	30	30	40	39	48	48	37	83	246.67	553.33
2.00 pm	33	29	41	40	48	48	25	108	166.67	720.00
3.00 pm	35	29	40	38	47	47	44	152	293.33	1013.33
4.00 pm	32	31	37	36	46	47	21	173	140.00	1153.33
5.00 pm	32	26	37	36	45	45	45	218	300.00	1453.33
6.00 pm	31	33	36	34	43	43	6	224	40.00	1493.33

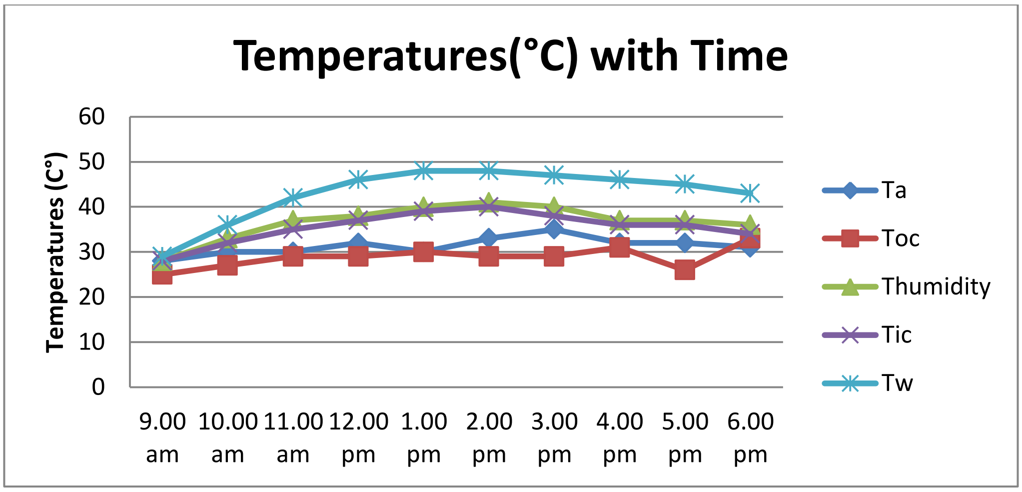
Table 10. Data for 18th July (sea sand)

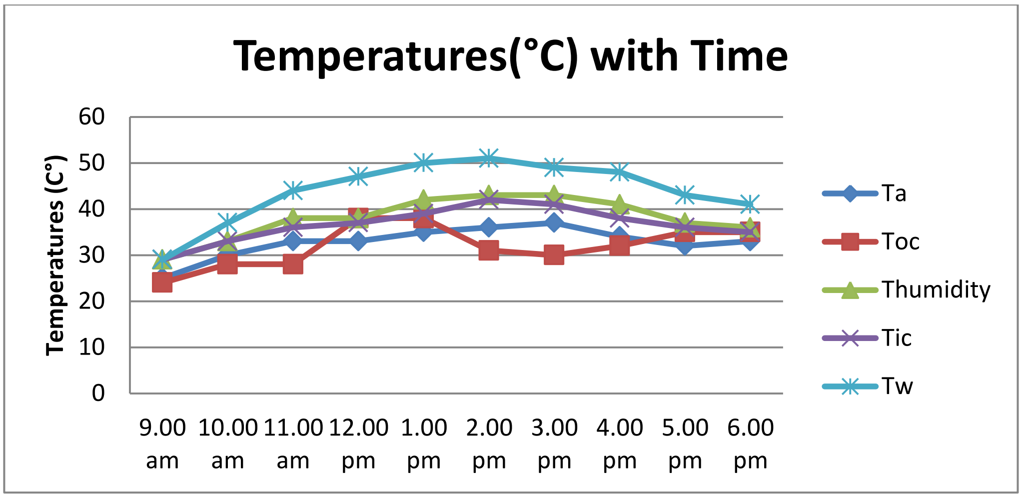
Time	T_a	T_{oc}	$T_{humidity}$	T_{ic}	T_w	T_b	W_{hexp} (ml)	W_{dexp} (cumulative) (ml)	W_{hexp} (ml/m²)	W_{dexp} (cumulative) (ml/m²)
9.00 am	25	24	29	29	29	29	0	0	0.00	0.00
10.00 am	30	28	33	33	37	37	7	7	46.67	46.67
11.00 am	33	28	38	36	44	44	14	21	93.33	140.00
12.00 pm	33	38	38	37	47	47	14	35	93.33	233.33
1.00 pm	35	38	42	39	50	50	44	79	293.33	526.67
2.00 pm	36	31	43	42	51	51	46	125	306.67	833.33
3.00 pm	37	30	43	41	49	49	30	155	200.00	1033.33
4.00 pm	34	32	41	38	48	48	32	187	213.33	1246.67
5.00 pm	32	35	37	36	43	43	26	213	173.33	1420.00
6.00 pm	33	35	36	35	41	41	19	232	126.67	1546.67

Table 11. Data for 19th July (sea sand)

Time	T_a	T_{oc}	$T_{humidity}$	T_{ic}	T_w	T_b	W_{hexp} (ml)	W_{dexp} (cumulative) (ml)	W_{hexp} (ml/m²)	W_{dexp} (cumulative) (ml/m²)
9.00 am	26	25	25	25	26	26	0	0	0.00	0.00
10.00 am	29	26	33	33	35	35	14	14	93.33	93.33
11.00 am	31	28	39	37	45	45	9	23	60.00	153.33
12.00 pm	34	32	40	39	47	47	30	53	200.00	353.33
1.00 pm	33	32	42	40	49	49	35	88	233.33	586.67
2.00 pm	32	33	42	37	49	49	45	133	300.00	886.67
3.00 pm	31	32	39	35	48	48	35	168	233.33	1120.00
4.00 pm	33	35	40	34	46	46	35	203	233.33	1353.33
5.00 pm	31	34	36	34	42	42	46	249	306.67	1660.00
6.00 pm	31	32	34	34	39	39	13	262	86.67	1746.67

Table 12. Data for 20th July (sea sand)





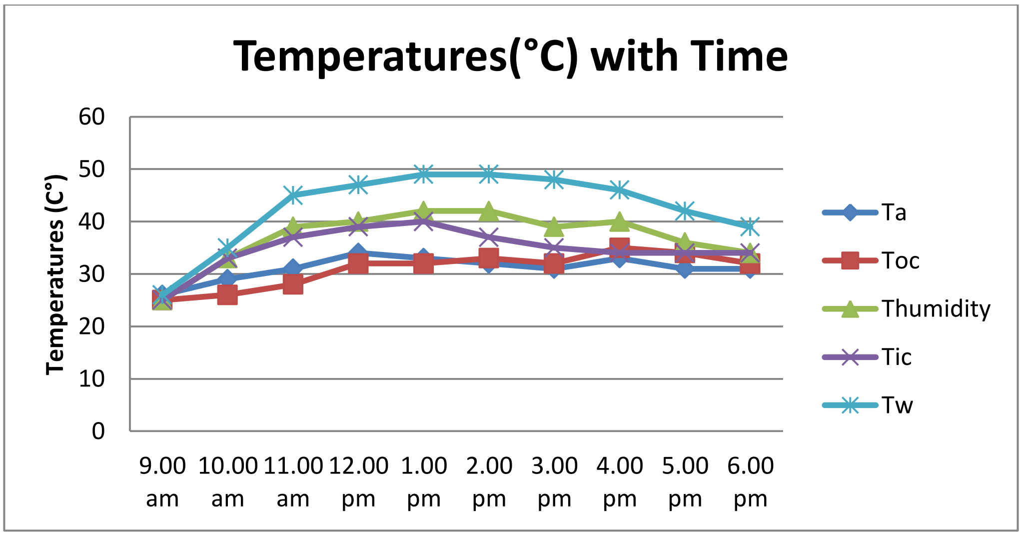


Figure 14. Graphs Temperature (°C) with Time

(18th,19th,and20th July) –sea sand-

4.5 Daily distilled water production

9am – 6pm

	18-Jul	19-Jul	20-Jul
CONVENTIONAL (ml)	125	106	134
BLACK SOIL (ml)	293	279	275
SEA SAND (ml)	224	232	262

7pm – 9am

	18-Jul	19-Jul	20-Jul
CONVENTIONAL (ml)	0	29	38.2
BLACK SOIL (ml)	0	54	42
SEA SAND (ml)	0	61	63

Table 13. Daily distilled water production

The three days experiment was done in order to evaluate the performance of the basin with black soil and sea sand layer in producing potable water. Black soil and sea sand are tested for the ability of the absorptivity of heat by solar energy. Black soil is tested for due to the natural effects of the color being able to absorb and release heat fast. Sea sand layer is tested for its opaque and non-reflective properties. As we can see from **Table 14**, the production of water from black soil is higher at 9am to 6pm while the production of water at 7pm to 9am is higher by using sea sand layer basin. During the day, black soil can absorb heat more than sea sand layer. Thus, rate of evaporation are high and more water are produce. At night, sea sand keep more hear since the sea sand are not be able to release heat as faster as the black soil. Due to this condition, by using sea sand layer at night, more water are produced which including the dew or the condensation vapor during the night.

Other than that, the weather condition on the specific day also influence the result obtained. During the experiment duration, the range of the weather is from sunny to cloudy, windy to hot as well as a drizzle of rain.

From **Table 3** and **Figure 4**, we can see that the ambient temperature for three consecutive days which is on 18^{th}, 19th and 20^{th} July 2014 is not much different. As we know, Malaysia condition is hot and humid throughout the year. Thus, there should not be any problem to solar still to be practical in Malaysia especially. The weather during the period of experiment is not constantly sunny. But there is still water production collected during that weather. The result from the cloudy weather is the temperature of the solar still drop which decreasing the evaporation rate where water production also decreasing.

From the all the results obtained, the temperature of outer cover and ambient are closely similar. This showed that a gradual increase from morning to afternoon and declined in the evening. On the other hand, the inner cover temperature is relative with the humidity temperature of the solar still. Normally, the inner cover temperature is lower than the humidity temperature as cover is being cooled by the ambient temperature.

Furthermore, from the results obtained, it is identified that the water collector for the solar still system must be designed properly and carefully in order to ensure accurate measuring are obtain.

4.5 Water Quality

	lake water
pH	6.78
Total dissolved solids (mg/l)	250
Nitrate(mg/l)	1 mg/L
Sulfate(mg/l)	2.37 mg/L
Iron(mg/l)	18.67 mg/L
Turbidity(mg/l)	0.98 mg/L
Color (Hazen unit)	8
E.coli	Present

Table 14. Result for water quality test (lake water)

Figure 15. Lake Water

	conventional	black soil	sea sand
pH	6.63	6.51	6.61
Total dissolved solids (mg/l)	250	380	300
Nitrate(mg/l)	1 mg/L	0.6 mg/L	0.4 mg/L
Sulfate(mg/l)	0 mg/L	1 mg/L	0 mg/L
Iron(mg/l)	0.15 mg/L	0.17 mg/L	0.08 mg/L
Turbidity(mg/l)	2.62NTU	3.77 NTU	1.40 NTU
Color (Hazen unit)	0	0	0
E.coli	-	-	-

Table 15. Result for water quality test (water collected)

Parameter	
pH	6.5-8
Total dissolved solids (mg/l)	<600
Nitrate(mg/l)	50
Sulfate(mg/l)	250
Iron(mg/l)	0.3
Turbidity(mg/l)	<5
Color (Hazen unit)	<5
E.coli	-

Table 16. WHO standard water quality

The qualities of water for the water sample collected are much different from the quality of the lake water which is after the distillation of the lake water, the water quality are improved. From **Table 15**, it is identified that the water collected from the experiments done are drinkable. The result obtained showed that all the parameters tested meet all the standard requirement of World Health Organization (WHO) for drinking water quality.

As stated in Guideline for Drinking Water Quality, the minimum monitoring which also can be define as the critical parameters of water quality recommended are e.coli which must not be detectable in any 100-ml sample, pH value of the sample which must ranging between 6.5 to 8 and also the turbidity of the water which must be less than 5 NTU. The standard water quality is shown in **Table 16**.

However, the result obtained might be not accurate enough. This is due to human error occurred whether during water sample is collected or during doing the laboratory testing. Thus, several precautions need to take in order to ensure the result obtain are accurate. For example, as mentioned before, water collected tank must be design properly to avoid any unnecessary particles mix into the sample and also more reading must be taken during water quality test.

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CHAPTER 5

CONCLUSION AND RECOMMENDATION

Solar still system with black soil basin produce highest cumulative water production of 1953.33 ml/m² water production compared to 893.33 ml/m² and 1746.67 ml/m² for conventional and sea sand basin. As the temperature increase, the volume of water collected also increase. It is concluded that several modification must be done in order to determine the most efficient parameters that can enhancing the production of potable water using solar still system. Other that, in order to have more accurate result, comparison between different variables used must always use the same type of water. Therefore, volume of potable water collected can be compare accurately. More experiments must be done in order to determine the most efficient parameters that can enhance the production of potable water using solar still system. Fabrication of the solar still system must be done carefully and nicely to avoid any error during running the experiments. In order to have more efficient solar still system, experiment on combination of black soil and sea sand layer basin must be done since during the day, black soil can absorb more heat and during night sea sand still capable to store heat which better than black soil. Thus, more water production will obtain. Overall, solar still water production under Malaysia conditions has potential to grow as even during the cloudy weather, solar still can also produce high production.

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APPENDICES

APPENDIX 1: Water collector

APPENDIX 2: Three Solar Still System with different materials in the basin

APPENDIX 3: Evaporation-condensation process in basin

APPENDIX 4: Example of water quality test.