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Theoretical and Experimental Study for Solar Powered Atmospheric Water Generation Using Peltier's Device.

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ABSTRACT

Potable water shortages are one of today's world's most critical problems. While water covers more than two-thirds (about 71%) of the earth's surface, works suitable for everyday usage are still scarce (only about 2.75 percent). Countries with long coastlines and island states that do not have adequate freshwater facilities, such as rivers and wetlands, face the acute water scarcity crisis. This paper conducts an experimental and theoretical analysis for an atmospheric water generation system. The unit is based on the thermoelectric cooling theory, with solar energy as the system's power source. The experimental work is conducted at Basra Region, located in southern of Iraq, between August and September 2019 and March 2020. Different climatic conditions test the experimental system on different days. Maximum water production is 3.4 L/day from all test days for various hours of service when relative humidity varies from (45-95 percent), and temperature ranges from 17C to 45C. Results indicate that water production rate increases with increasing humidity, temperatures, and hours of service and model area

1. Introduction

Countries primarily face severe water scarcity issues with long coastlines and island states that do not have adequate freshwater facilities, such as rivers and ponds. As a result, most of these countries satisfy their water needs by desalinizing seawater, which is expensive. There is also an immediate need to find new ways to produce water to fulfill its water protection needs. The purpose of this research is to solve this problem. The relative humidity (RH) is very high in coastal areas (about 70% - 80 %). The air in coastal regions can also meet people's water needs with a dehumidifier device. Also, the sun's rays are very high all year round in these regions. This can be used to supply the energy needed for the dehumidification device. It is also possible to extract usable water from the air by using solar energy. [1],[2].

The research aims to create a model that can be used to meet water requirements. The form will condense the water present in the atmosphere and then purify it so that it is suitable for human use. During the atmospheric water generator design, requirements were identified to ensure that the research effectively fulfilled its intended purpose.

1- The possibility of using water - the water produced by design must comply with the World Health Organization (WHO) drinking water quality standards.
2- The simplicity of use - the design should be operable by persons with limited technical experience.
3- Safety - the design should not pose a danger to users at any time during regular operation.
4- Flexibility in the energy source - The design should use various energy sources, including (but not limited to) solar, wind, and conventional power grids.
5- Maximizing efficiency - the design should increase the water produced per unit of energy.
6- Reducing the cost - the design should reduce the cost of producing one water unit each Capital cost and production cost. [1],[2].

Bogardi, J. J., et al. (2012). Sustainability, fair distribution, and conservation of water resources must occur within integrated water management and governance, but their implementation is problematic. Continuing global climate change, growing population, urbanization, and striving for better living conditions pose a challenge to planetary sustainability. **[2]. Kabeel, A., et al. (2016).** An alternative method for the recovery of fresh water from the atmosphere has been studied. The approach studied is planned for Arab Gulf countries or similar by using solar thermometric generator utilization. The presence of solar energy and humid air offers a strong chance of successful productivity. The mathematical model will now provide a fair representation of the various cases. The use of recent numerical modeling is versatile enough to produce reliable results without expense and time savings. For simplification, the patients studied were expected to be the fluid flow area, which means that the simulation would not be part of the Multiphysics. The environmental conditions were considered to be the design parameters. The three climate areas are the Red Sea, the Arab Gulf, and Southern Europe (south Spain). Only the summer climate conditions are considered. It was found that the pumping power needed for the air ventilator did not exceed 9,1 W. The unit's freshwater efficiency was up to 3.9 L/h/m^2. **[3]. Liu, S., et al. (2017).** Two thermoelectric coolers (TECs) were developed and tested for portable water generators (7 kg). Different inlet air relative humidity (RH) and airflow rates have been analyzed to affect the amount of water and condensation produced. The amount of water paid and the quality of condensation increased with an increase in RH. The amount of water produced increased with rising airflow rates, but the condensation rate was the opposite. The maximum amount of water produced was 25.1 g per hour with a condensation surface of 0.216 m^2 and an input power of 58.2 W. This device was small in size and could function at low airflow rates appropriate for outdoor use. This research had a leading role in the design and optimization of a portable high-efficiency water generator.**[4]. Scrivani, A. and U. Bardi (2008).** the investigated project aims to explore the use of solar concentrating plants in Mediterranean countries to supply renewable water. The method presented in his study is the extraction of water from the air by direct cooling of humid air below the dew point. **[5]. A.Bharath K. Bhargav (2017).** An Atmospheric Water Generator is fit for changing over barometrical dampness straightforwardly into usable and, in any event, drinking water. The air-water generator comprises a draft fan, heat sink, packaging, and a thermoelectric Peltier (TEC) coupler**. [6].**

2. Experimental device

2.1 Components used

The components used for the construction of the water generation device are as shown below:

Table 1: shows the details of the model of paper.

Item No.	Component name	QTY	Specification	Fig. No.
1	A draft fan in the cooled side	2	DC 12V 0.16 Amp	3
2	Draft fan in hot side	1	12 VDC	2
3	Peltier	3	TECI- 12715	2
4	cover	1	plastic sheet	1
5	Casing	1	Insulated plastic	1
6	Battery	1	60AH 12VDC	1
7	Solar cell	1	MODEL: SY-S060W	1

2.2 Description

The casing is divided into three chambers. The inlet air is passed through the left section into the bottom chamber, where it comes in contact with the Peltier device's cold surface. The Inlet Atmospheric air thus loses heat, and its temperature falls to the TDP, and therefore water vapor starts condensing. The dehumidified air is then expelled from the device through the right chamber. The lower part also acts as a water collecting unit. Condensed water vapor from the bottom part is contained in a quieter part by dripping action, as the gravitational force pulls down water droplets. It can be seen as given in figures no.1,2,3,4,5 and 6.

Figure 1: Details of system no.1

Figure 2: Details of a Draft fan on the hot side

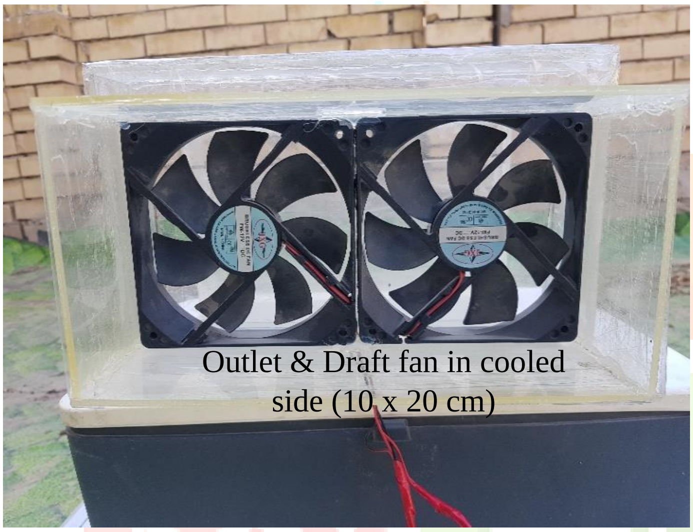


Figure 3: The sketch of a Draft fan in the cooled side

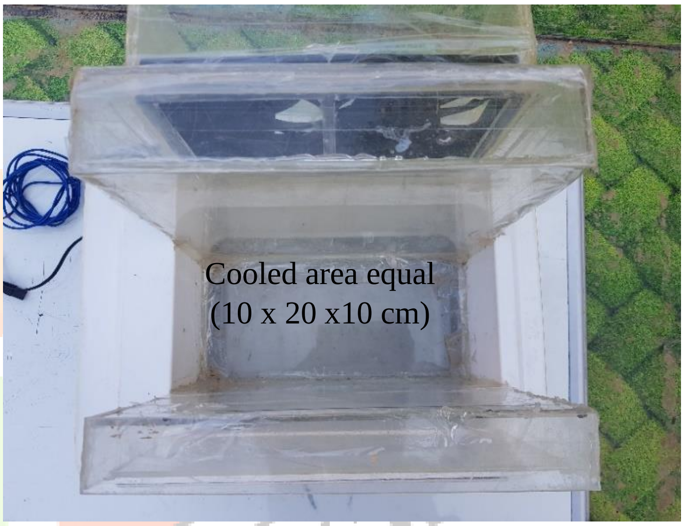


Figure 4: Details of cooled area

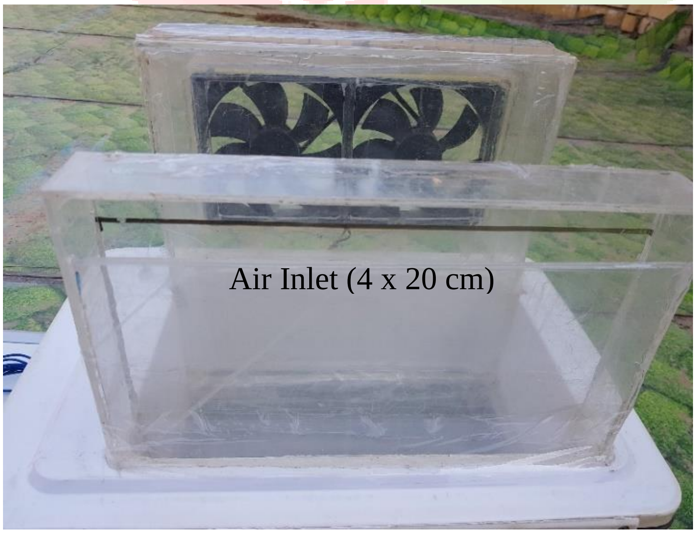


Figure 5: Details of an inlet of the air

Figure 6: Actual Picture during Activities

2.3 Measuring instruments

The experiments used during the experiments are Anemometer-Psychometry, infrared thermometer, and temperature-humidity meter, shown in figureNo.7.

Figure 7: Measuring instruments

3. Theoretical analysis

The underlying technology that permits the construction of these thermoelectric assemblies is now referred to as "The Peltier Effect." It uses two elements of a semiconductor. Upon applying a direct current (DC) power source, these devices generate a cooling action, countered by a generation of heat on the device's opposite side. Peltier's assemblies use thermoelectric "modules" sandwiched between high-performance aluminum heat sinks and one or more high axial fans. Peltier's bodies coupled with a patented electronic design to "pump" the heat from the inside of an enclosure to the outside without exposing delicate electronics to any outside air or contamination. Through proper packaging [7]. This can be seen in figureNo.8.

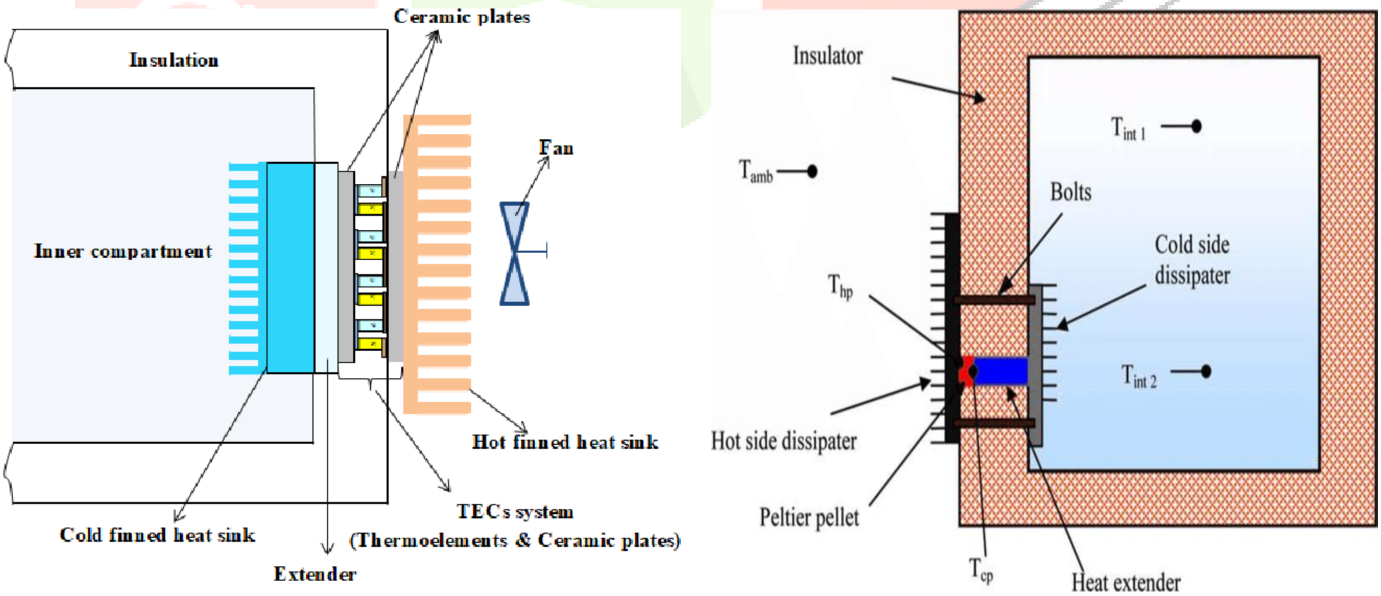


Figure 8: sample of diagrams for Peltier's devices

Theoretical prediction of available water vapor in the air

The following relations give the necessary dew point temperature required for water vapor condensation, which is accomplished by the Peltier gadget for different temperature and relative humidity;

$$\beta(T,RH) = \ln\left(\frac{RH}{100}\right) + \frac{aT}{b+T} \quad \text{-------------------------------- (eq.1)}$$

$$T_{dp} = \frac{b\beta(T,RH)}{a-\beta(T,RH)} \quad \text{-- (eq.2)}$$

Where:

(a = 17.67 & b= 243.5 and T is in C)

The ratio of (m_v/m_a) is defined as humidity ratio denoted by the term of (W) is "the mass of Vapour associated with one Kg of dry air " also known as mixing ratio or moisture content and is given by [8].

$$W = \frac{V_{as}}{V_s} = \frac{287(273+t_d)}{(P_b-P_s)V_s}$$ --- **(eq.3)**

When (t_d) is also the saturation temperature, and the partial pressure of air is P_s, the moisture content is given by;

$$W_s = 0.622\,\frac{P_s}{(P_b-P_s)} = \frac{Kg}{Kg}\,of\ dry\ air$$ ----------------------------------- **(eq.4)**

Where:

W_s = moisture required to saturate 1 Kg of dry air

P_s = saturated pressure of vapor corresponding to dry bulb temperature from the steam table. **[12].**

3.3 TDS Testing

Three different samples were taken and examined by the TDS tester, and the results appeared as in the table below, which can be seen in the product: see figure. In such a case, the purity of the water produced by air after is good, and it can be used, and it can also be filtration, treated by adding healthy mineral salts to be drinkable.

Liquefaction water/ TDS = 591 Mineral water RO/ TDS = 83 Generation Water from air/ TDS = 58

Figure 9: Actual Picture during Activities attested

4. Results and Discussion

4.1 General

In this section, the obtained results will be viewed. Firstly, the experimental results have been taken in August and September during 2019 and spring from 2020. The number of experiments performed is (90) experiments. The time required for each experiment is (three-hour at minimum to 21 hours at maximum) during the day of operation, the variation of dry temperature (DBT) from 17℃ to 45℃, and the variation of relative humidity (RH) from 25% to 98%. But, had been chosen in this paper only from 60% to 90%. The theoretical prediction for the variation of water vapor content in the air for different dry bubble temperatures and relative humidity is also given to verify and compare it with experimental results.

4.2 Case 1 (Experimental Case)

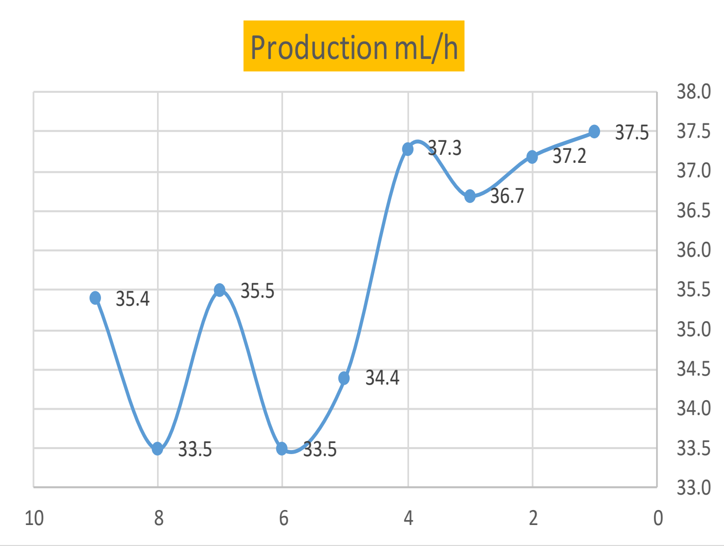
Actual operation tests for the water generation device had been performed for two months in 2019 and one month in 2020 (from 01-08-2019 to 30-09-2019) and (01-03-2020 to 31-03-2020). Closed: The range of relative humidity between (60% -90%) and temperature between (17℃-45℃), so that water is collected every hour, representing the amount of water within one day for the indicated temperatures humidity. The range of water production rate for the experiments performed in August and September from 2019 is from 0.4 L/day to 3.4L/day, which can be seen in Table no.3, which is suitable for the experimental device's size. The water production rate is increased with an increase in humidity at the range of temperatures available. The content of water production rate for the experiments that were performed in spring from 2020 is from 232.2 mL/day to 1323.6 mL/day. Can be seen in Tables & charts no.2, which are suitable for the experimental device's size. All the experiments are done using just three of Peltier's elements. The humidity in the air is not the same every time, and the conditions are not even similar, so the amount of water produced is not the same. The variation of water production rate with relative humidity and temperature is shown in the Tables & Charts no.2 below. The water production rate for constant dry bulb temperature increased with increasing the relative humidity from the tables. Also, the water production rate for constant relative humidity increased with increasing the dry-bulb temperature. High values of relative humidity and dry bulb temperature increasing the hours of operation led to expanding the water production rate.

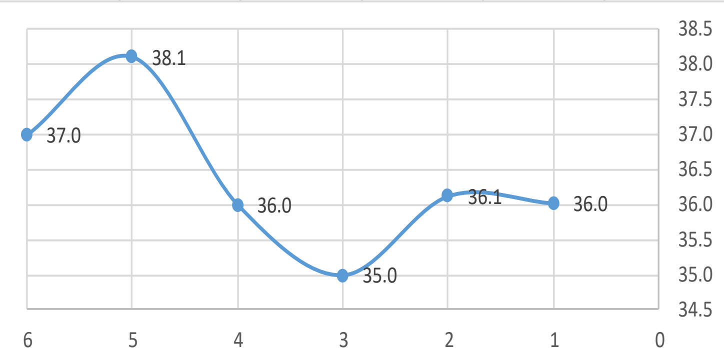
4.3 Case 2 (Theoretical Case)

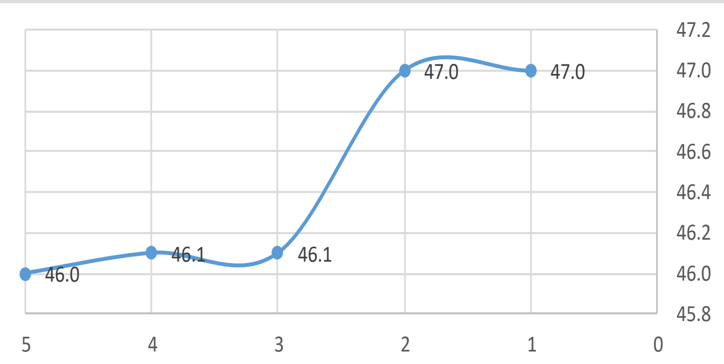
Theoretical predictions for the dew point temperature obtaining by the Peltier gadget and the percentage of moisture and the amount of water in the metric square of air will be viewed. The calculations are performed for different values of relative humidity and dry bulb temperature in the range of (45-100%) and (15-50 C), respectively. The results are given in tables 4,5,6,7 and 8, and in figure 10. The theoretical predictions are consistent with the experimental results. The behaviors are the same as that of the experimental results for increasing the water production with increasing the temperature and relative humidity.

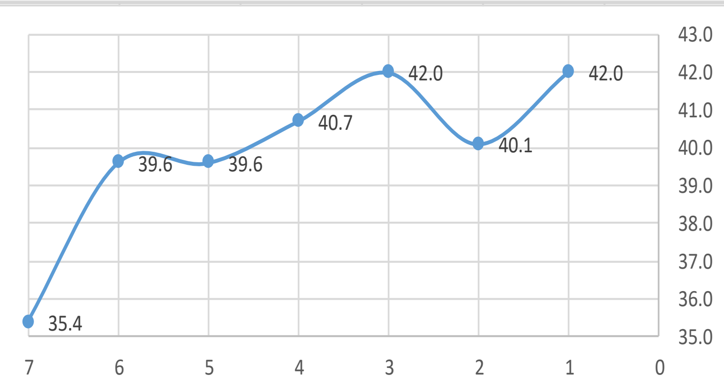
Tables & beside Charts (2): The amount of water present at different Temp. And different R.H. according to production different hours.

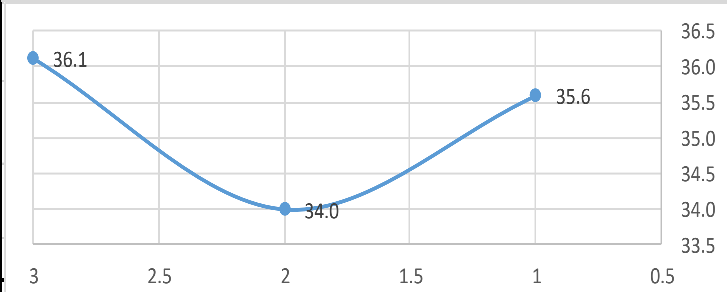
day	Time (h)	EXP. DBT (C)	EXP. DPT (C)	EXP. RH (%)	Production mL/h
05/03/2020	12:00 am	16	8	60	37.5
	1:00 am	15	8	63	37.2
	2:00 am	14	8	66	36.7
	3:00 am	14	8	67	37.3
	4:00 am	13	7	66	34.4
	5:00 am	12	7	69	33.5
	6:00 am	12	7	73	35.5
	7:00 am	12	7	69	33.5
	8:00 am	15	7	60	35.4
Amount of production for day according to (10) production hours					321.0
06/03/2020	2:00 am	15	7	61	36.0
	3:00 am	14	8	65	36.1
	4:00 am	14	7	63	35.0
	5:00 am	13	7	69	36.0
	6:00 am	13	8	73	38.1
	7:00 am	13	8	71	37.0
Amount of production for day according to (6) production hours					218.2
07/03/2020	3:00 am	19	11	61	47.0
	4:00 am	19	11	61	47.0
	5:00 am	18	11	63	46.1
	6:00 am	18	11	63	46.1
	7:00 am	19	11	60	46.0
Amount of production for day according to (5) production hours					232.2
09/03/2020	1:00 am	17	10	63	42.0
	2:00 am	16	10	64	40.1
	3:00 am	16	10	67	42.0
	4:00 am	16	9	65	40.7
	5:00 am	15	9	67	39.6
	6:00 am	15	9	67	39.6
	7:00 am	15	9	60	35.4
Amount of production for day according to (7) production hours					279.4
10/03/2020	5:00 am	14	6	64	35.6
	6:00 am	14	7	61	34.0
	7:00 am	14	7	65	36.1
Amount of production for day according to (3) production hours					105.6



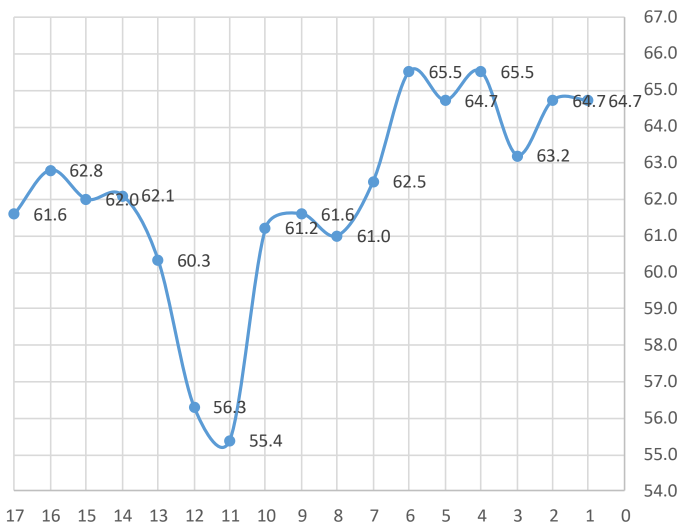


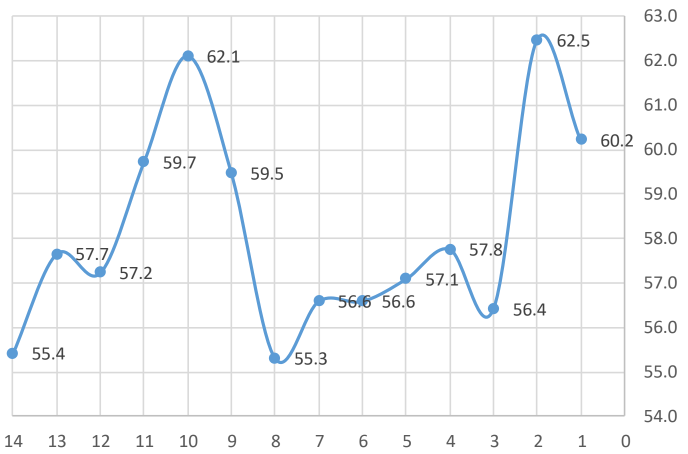


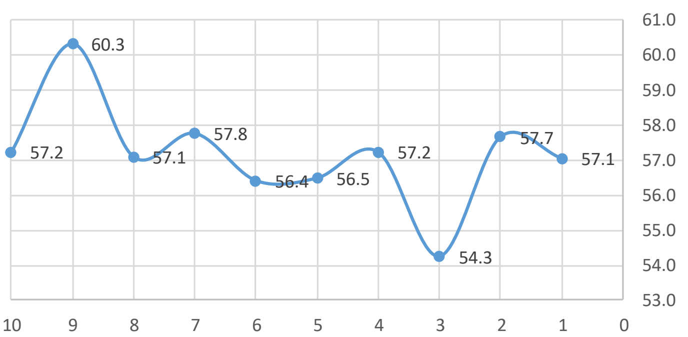


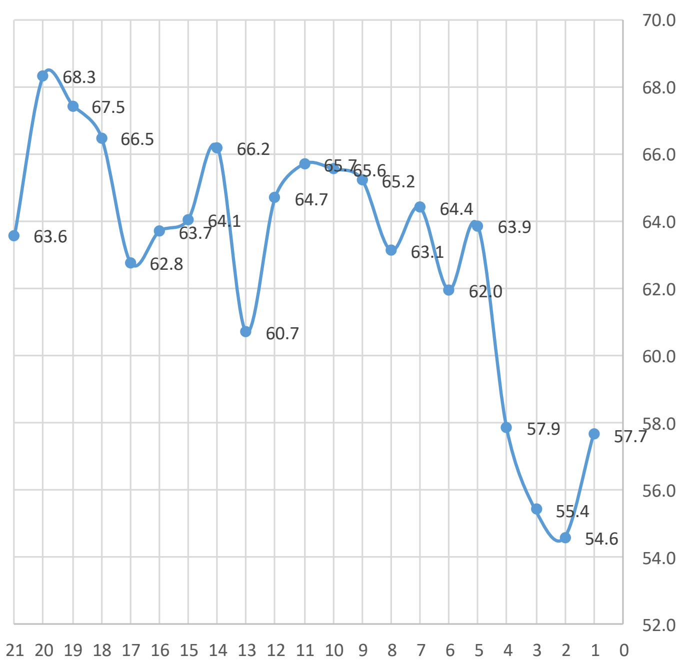


15/03/2020	12:00 am	19	16	84	64.7
	1:00 am	19	16	84	64.7
	2:00 am	18	16	86	63.2
	3:00 am	18	16	89	65.5
	4:00 am	18	16	88	64.7
	5:00 am	18	16	89	65.5
	6:00 am	18	16	85	62.5
	7:00 am	18	15	83	61.0
	8:00 am	19	16	80	61.6
	9:00 am	21	15	70	61.2
	10:00 am	22	15	61	55.4
	6:00 pm	22	15	62	56.3
	7:00 pm	21	15	69	60.3
	8:00 pm	21	15	71	62.1
	9:00 pm	20	16	77	62.0
	10:00 pm	20	16	78	62.8
	11:00 pm	19	15	80	61.6
Amount of production for day according to (17) production hours					1055.2
16/03/2020	12:00 am	18	15	82	60.2
	1:00 am	18	15	85	62.5
	2:00 am	17	15	85	56.4
	3:00 am	17	15	87	57.8
	4:00 am	17	14	86	57.1
	5:00 am	16	14	90	56.6
	6:00 am	16	14	90	56.6
	7:00 am	16	14	88	55.3
	8:00 am	18	15	81	59.5
	9:00 am	21	15	71	62.1
	10:00 am	23	15	61	59.7
	9:00 pm	22	15	63	57.2
	10:00 pm	21	15	66	57.7
	11:00 pm	20	15	69	55.4
Amount of production for day according to (14) production hours					814.1
17/03/2020	12:00 am	20	14	71	57.1
	1:00 am	19	15	75	57.7
	2:00 am	18	14	74	54.3
	3:00 am	18	14	78	57.2
	4:00 am	18	14	77	56.5
	5:00 am	17	14	85	56.4
	6:00 am	17	14	87	57.8
	7:00 am	17	15	86	57.1
	8:00 am	20	15	75	60.3
	9:00 am	22	15	63	57.2
Amount of production for day according to (10) production hours					571.5
18/03/2020	12:00 am	21	14	66	57.7
	1:00 am	20	14	68	54.6
	2:00 am	20	14	69	55.4
	3:00 am	20	15	72	57.9
	4:00 am	21	16	73	63.9
	5:00 am	20	16	77	62.0
	6:00 am	20	16	80	64.4
	7:00 am	19	16	82	63.1
	8:00 am	20	17	81	65.2
	9:00 am	22	16	72	65.6
	10:00 am	23	16	67	65.7
	11:00 am	23	16	66	64.7
	12:00 pm	23	16	62	60.7
	1:00 pm	24	16	63	66.2
	5:00 pm	24	16	61	64.1
	6:00 pm	23	16	65	63.7
	7:00 pm	22	16	69	62.8
	8:00 pm	22	16	73	66.5
	9:00 pm	21	17	77	67.5
	10:00 pm	21	17	78	68.3
	11:00 pm	20	16	79	63.6
Amount of production for day according to (21) production hours					1323.6

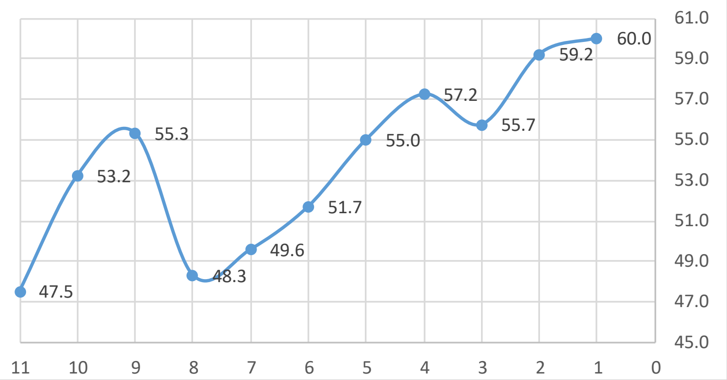


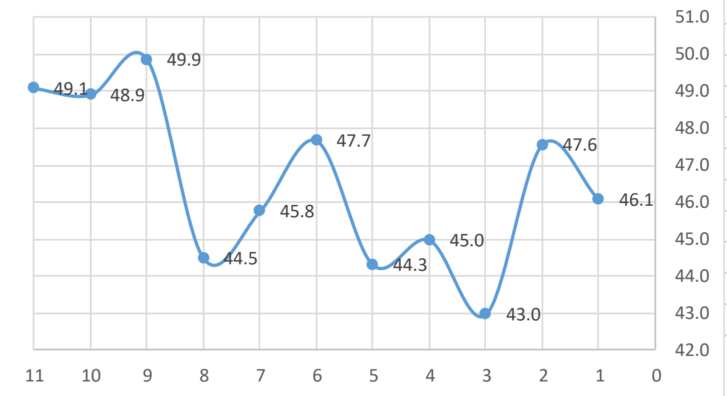


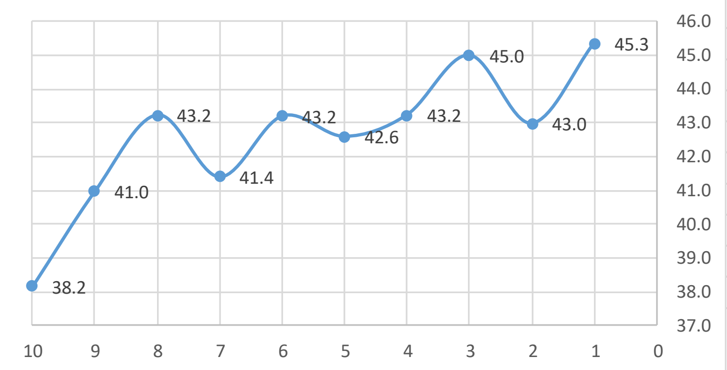


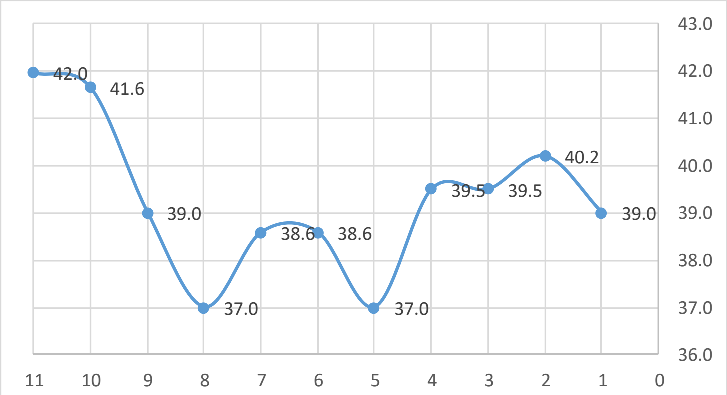


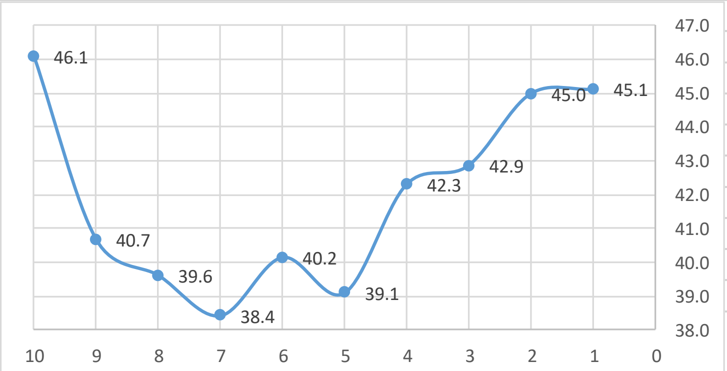
19/03/2020	12:00 am	19	15	78	60.0
	1:00 am	19	15	77	59.2
	2:00 am	18	14	76	55.7
	3:00 am	18	14	78	57.2
	4:00 am	18	13	75	55.0
	5:00 am	17	13	78	51.7
	6:00 am	16	12	79	49.6
	7:00 am	16	12	77	48.3
	8:00 am	19	13	72	55.3
	9:00 am	21	13	61	53.2
	11:00 pm	19	12	62	47.5
Amount of production for day according to (11) production hours					592.9
20/03/2020	12:00 am	18	11	63	46.1
	1:00 am	18	11	65	47.6
	2:00 am	17	10	65	43.0
	3:00 am	17	11	68	45.0
	4:00 am	17	11	67	44.3
	5:00 am	17	11	72	47.7
	6:00 am	16	11	73	45.8
	7:00 am	16	11	71	44.5
	8:00 am	19	12	65	49.9
	10:00 pm	20	12	61	48.9
	11:00 pm	19	12	64	49.1
Amount of production for day according to (11) production hours					511.7
22/03/2020	1:00 am	18	10	62	45.3
	2:00 am	17	10	65	43.0
	3:00 am	17	11	68	45.0
	4:00 am	16	11	69	43.2
	5:00 am	15	10	72	42.6
	6:00 am	15	10	73	43.2
	7:00 am	15	10	70	41.4
	8:00 am	16	10	69	43.2
	9:00 am	17	9	62	41.0
	11:00 pm	16	8	61	38.2
Amount of production for day according to (10) production hours					426.1
23/03/2020	12:00 am	15	9	66	39.0
	1:00 am	15	9	68	40.2
	2:00 am	14	9	71	39.5
	3:00 am	14	9	71	39.5
	4:00 am	13	8	71	37.0
	5:00 am	13	8	74	38.6
	6:00 am	13	8	74	38.6
	7:00 am	13	8	71	37.0
	8:00 am	15	9	66	39.0
	10:00 pm	17	10	63	41.6
	11:00 pm	16	10	67	42.0
Amount of production for day according to (11) production hours					432.0
24/03/2020	12:00 am	16	11	72	45.1
	1:00 am	15	11	76	45.0
	2:00 am	14	10	77	42.9
	3:00 am	14	10	76	42.3
	4:00 am	13	9	75	39.1
	5:00 am	13	9	77	40.2
	6:00 am	12	9	79	38.4
	7:00 am	13	9	76	39.6
	8:00 am	16	10	65	40.7
	11:00 pm	18	11	63	46.1
Amount of production for day according to (10) production hours					419.4



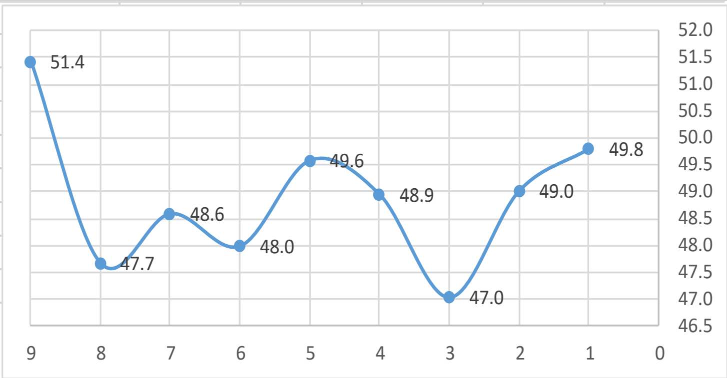


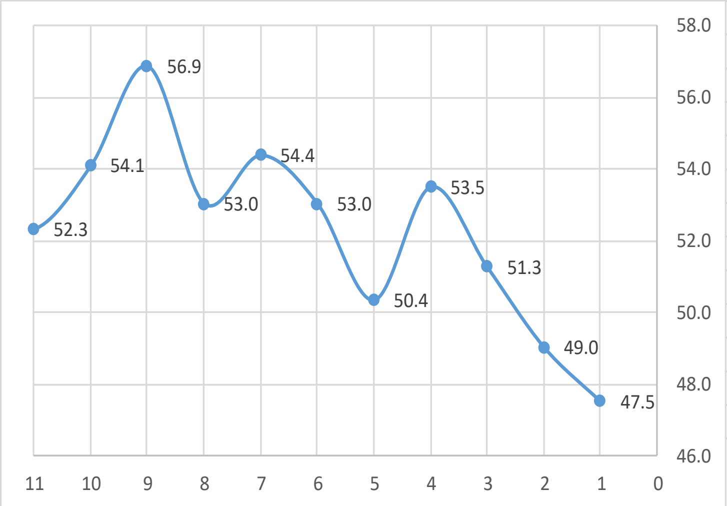


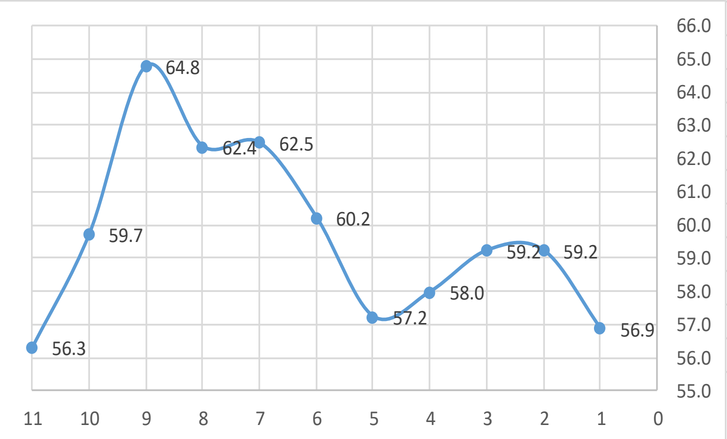


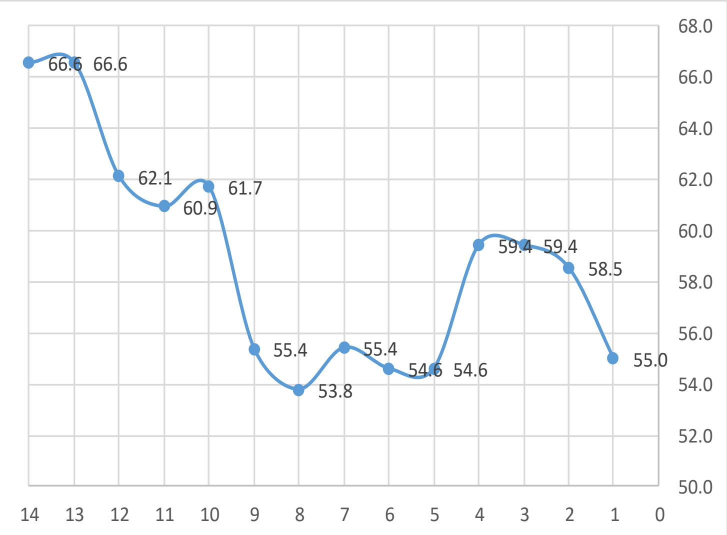


25/03/2020	12:00 am	18	12	68	49.8
	1:00 am	17	12	74	49.0
	2:00 am	16	12	75	47.0
	3:00 am	16	12	78	48.9
	4:00 am	16	12	79	49.6
	5:00 am	15	12	81	48.0
	6:00 am	15	12	82	48.6
	7:00 am	16	12	76	47.7
	8:00 am	19	13	67	51.4
Amount of production for day according to (9) production hours					440.0
26/03/2020	12:00 am	19	12	62	47.5
	1:00 am	18	12	67	49.0
	2:00 am	18	13	70	51.3
	3:00 am	18	13	73	53.5
	4:00 am	17	13	76	50.4
	5:00 am	17	13	80	53.0
	6:00 am	17	14	82	54.4
	7:00 am	17	14	80	53.0
	8:00 am	19	14	74	56.9
	9:00 am	21	14	62	54.1
	9:00 pm	21	13	60	52.3
	10:00 pm	20	14	66	53.0
	11:00 pm	20	14	70	56.2
Amount of production for day according to (11) production hours					684.8
27/03/2020	12:00 am	19	15	74	56.9
	1:00 am	19	15	77	59.2
	2:00 am	19	14	77	59.2
	3:00 am	18	15	79	58.0
	4:00 am	18	14	78	57.2
	5:00 am	18	14	82	60.2
	6:00 am	18	15	85	62.5
	7:00 am	19	15	81	62.4
	8:00 am	21	16	74	64.8
	9:00 am	23	15	61	59.7
	11:00 pm	22	14	62	56.3
Amount of production for day according to (11) production hours					656.4
28/03/2020	12:00 am	21	14	63	55.0
	1:00 am	21	15	67	58.5
	2:00 am	21	15	68	59.4
	3:00 am	21	15	68	59.4
	4:00 am	20	14	68	54.6
	5:00 am	20	14	68	54.6
	6:00 am	20	14	69	55.4
	7:00 am	20	14	67	53.8
	8:00 am	22	14	61	55.4
	7:00 pm	23	15	63	61.7
	8:00 pm	22	15	67	60.9
	9:00 pm	21	16	71	62.1
	10:00 pm	21	17	76	66.6
	11:00 pm	21	16	76	66.6
Amount of production for day according to (14) production hours					824.1

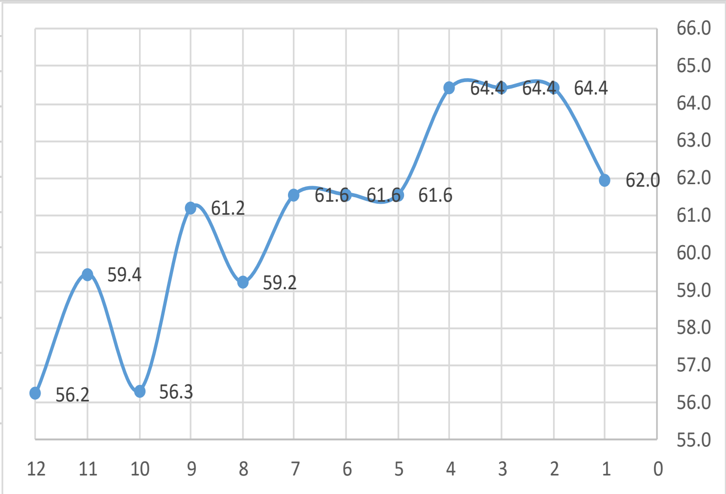


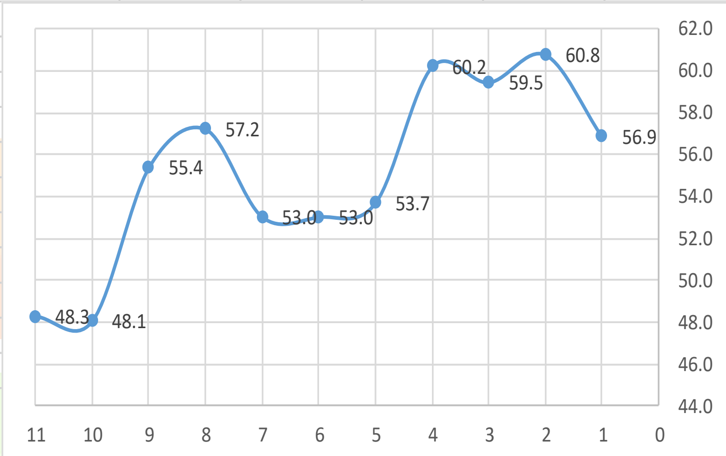






29/03/2020	12:00 am	20	16	77	62.0
	1:00 am	20	16	80	64.4
	2:00 am	20	16	80	64.4
	3:00 am	20	16	80	64.4
	4:00 am	19	16	80	61.6
	5:00 am	19	15	80	61.6
	6:00 am	19	15	80	61.6
	7:00 am	19	15	77	59.2
	8:00 am	21	15	70	61.2
	9:00 am	22	14	62	56.3
	10:00 pm	21	15	68	59.4
	11:00 pm	20	15	70	56.2
Amount of production for day according to (12) production hours					732.4
30/03/2020	12:00 am	19	15	74	56.9
	1:00 am	19	15	79	60.8
	2:00 am	18	15	81	59.5
	3:00 am	18	15	82	60.2
	4:00 am	17	14	81	53.7
	5:00 am	17	14	80	53.0
	6:00 am	17	14	80	53.0
	7:00 am	18	14	78	57.2
	8:00 am	20	14	69	55.4
	10:00 pm	20	12	60	48.1
	11:00 pm	19	12	63	48.3
Amount of production for day according to (11) production hours					606.2
31/03/2020	12:00 am	19	13	68	52.2
	1:00 am	18	13	70	51.3
	2:00 am	18	13	73	53.5
	3:00 am	18	13	73	53.5
	4:00 am	17	12	73	48.3
	5:00 am	17	13	73	48.3
	6:00 am	17	13	73	48.3
	7:00 am	18	13	70	51.3
	8:00 am	20	13	63	50.5
Amount of production for day according to (9) production hours					457.3





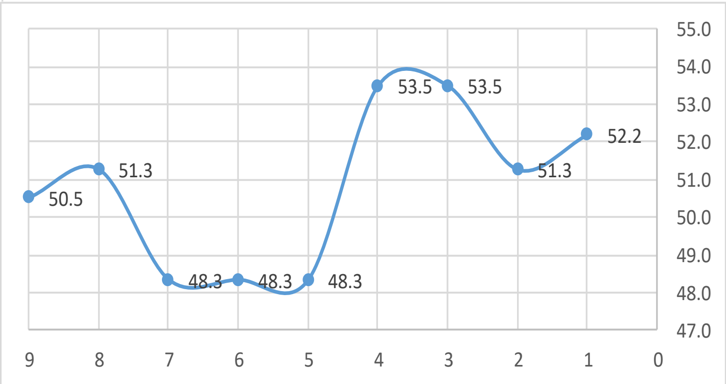


Table 3: The amount of water present at different Average Humidity Rates according to production hours.

EXP. Day	EXP. Hours	Average Humidity Rate (%)	Amount of water produced (L)
10-Aug-19	12	67	1.5
11-Aug-19	7	68	0.9
12-Aug-19	5	69	0.6
13-Aug-19	7	72	0.9
14-Aug-19	3	73	0.4
15-Aug-19	17	82	2.6
16-Aug-19	14	85	2.2
17-Aug-19	10	85	1.6
18-Aug-19	21	87	3.4
19-Aug-19	11	86	1.8
20-Aug-19	11	90	1.8
21-Aug-19	10	92	1.7
22-Aug-19	11	88	1.8
23-Aug-19	10	81	1.5
24-Aug-19	9	71	1.2
25-Aug-19	11	61	1.2
26-Aug-19	11	63	1.3
27-Aug-19	14	66	1.7
28-Aug-19	12	69	1.5
29-Aug-19	11	83	1.7
30-Aug-19	9	80	1.3
01-Sep-19	10	70	1.3
02-Sep-19	6	61	0.7
03-Sep-19	5	62	0.6
04-Sep-19	7	69	0.9
05-Sep-19	3	71	0.4
06-Sep-19	17	71	2.2
07-Sep-19	14	75	1.9
08-Sep-19	10	74	1.4
09-Sep-19	21	78	3.0
10-Sep-19	11	77	1.6
11-Sep-19	11	85	1.7
12-Sep-19	10	87	1.6
13-Sep-19	11	86	1.8
14-Sep-19	10	75	1.4
15-Sep-19	9	63	1.0
16-Sep-19	8	63	0.9
17-Sep-19	7	65	0.8
18-Sep-19	6	65	0.7
19-Sep-19	5	68	0.6
20-Sep-19	4	67	0.5
21-Sep-19	6	72	0.8

Table 4: Dew point temperature calculations at 25-50 C and different relative humidity conditions Temperature

Dry Bulb Temp. (C)	Relative Humidity (%)	Beta	Dew point Temp. (C)	DEF Temp.(C)
25	45	0.847	12.26	12.7442
26	45	0.906	13.16	12.8371
27	45	0.965	14.07	12.9302
28	45	1.024	14.98	13.0237
29	45	1.082	15.88	13.1175
30	45	1.14	16.79	13.2116
31	45	1.197	17.69	13.306
32	45	1.254	18.6	13.4008
33	45	1.31	19.5	13.4959
34	45	1.366	20.41	13.5913
35	45	1.422	21.31	13.687
36	45	1.477	22.22	13.783
37	45	1.532	23.12	13.8794
38	45	1.587	24.02	13.9761
39	45	1.641	24.93	14.073
40	45	1.695	25.83	14.1704
41	45	1.748	26.73	14.268
42	45	1.801	27.63	14.3659
43	45	1.854	28.54	14.4642
44	45	1.906	29.44	14.5628
45	45	1.958	30.34	14.6617
46	45	2.009	31.24	14.7609
47	45	2.06	32.14	14.8604
48	45	2.111	33.04	14.9603
49	45	2.162	33.94	15.0604
50	45	2.212	34.84	15.1609

Dry Bulb Temp. (C)	Relative Humidity (%)	Beta	Dew point Temp. (C)	DEF Temp.(C)
25	50	0.952	13.87	11.13
26	50	1.012	14.79	11.21
27	50	1.071	15.7	11.3
28	50	1.129	16.62	11.38
29	50	1.187	17.54	11.46
30	50	1.245	18.46	11.54
31	50	1.302	19.38	11.62
32	50	1.359	20.29	11.71
33	50	1.416	21.21	11.79
34	50	1.472	22.13	11.87
35	50	1.527	23.04	11.96
36	50	1.583	23.96	12.04
37	50	1.638	24.87	12.13
38	50	1.692	25.79	12.21
39	50	1.746	26.7	12.3
40	50	1.8	27.62	12.38
41	50	1.853	28.53	12.47
42	50	1.906	29.45	12.55
43	50	1.959	30.36	12.64
44	50	2.011	31.27	12.73
45	50	2.063	32.19	12.81
46	50	2.115	33.1	12.9
47	50	2.166	34.01	12.99
48	50	2.216	34.93	13.07
49	50	2.267	35.84	13.16
50	50	2.317	36.75	13.25

Dry Bulb Temp. (C)	Relative Humidity (%)	Beta	Dew point Temp. (C)	DEF Temp.(C)
25	55	1.047	15.34	9.657
26	55	1.107	16.27	9.727
27	55	1.166	17.2	9.798
28	55	1.224	18.13	9.87
29	55	1.283	19.06	9.941
30	55	1.34	19.99	10.01
31	55	1.398	20.92	10.08
32	55	1.455	21.84	10.16
33	55	1.511	22.77	10.23
34	55	1.567	23.7	10.3
35	55	1.623	24.62	10.38
36	55	1.678	25.55	10.45
37	55	1.733	26.48	10.52
38	55	1.787	27.4	10.6
39	55	1.842	28.33	10.67
40	55	1.895	29.26	10.74
41	55	1.949	30.18	10.82
42	55	2.002	31.11	10.89
43	55	2.054	32.03	10.97
44	55	2.106	32.96	11.04
45	55	2.158	33.88	11.12
46	55	2.21	34.81	11.19
47	55	2.261	35.73	11.27
48	55	2.312	36.65	11.35
49	55	2.362	37.58	11.42
50	55	2.412	38.5	11.5

Dry Bulb Temp. (C)	Relative Humidity (%)	Beta	Dew point Temp. (C)	DEF Temp.(C)
25	60	1.134	16.71	8.29464
26	60	1.194	17.64	8.35558
27	60	1.253	18.58	8.41674
28	60	1.311	19.52	8.47811
29	60	1.37	20.46	8.53969
30	60	1.427	21.4	8.6015
31	60	1.485	22.34	8.66351
32	60	1.542	23.27	8.72575
33	60	1.598	24.21	8.7882
34	60	1.654	25.15	8.85086
35	60	1.71	26.09	8.91374
36	60	1.765	27.02	8.97684
37	60	1.82	27.96	9.04015
38	60	1.874	28.9	9.10368
39	60	1.929	29.83	9.16742
40	60	1.982	30.77	9.23137
41	60	2.036	31.7	9.29555
42	60	2.089	32.64	9.35993
43	60	2.141	33.58	9.42453
44	60	2.193	34.51	9.48935
45	60	2.245	35.45	9.55438
46	60	2.297	36.38	9.61963
47	60	2.348	37.31	9.68509
48	60	2.399	38.25	9.75076
49	60	2.449	39.18	9.81665
50	60	2.499	40.12	9.88275

Dry Bulb Temp. (C)	Relative Humidity (%)	Beta	Dew point Temp. (C)	DEF Temp.(C)
25	65	1.214	17.97	7.029
26	65	1.274	18.92	7.081
27	65	1.333	19.87	7.133
28	65	1.392	20.82	7.185
29	65	1.45	21.76	7.237
30	65	1.507	22.71	7.29
31	65	1.565	23.66	7.342
32	65	1.622	24.6	7.395
33	65	1.678	25.55	7.448
34	65	1.734	26.5	7.501
35	65	1.79	27.45	7.555
36	65	1.845	28.39	7.609
37	65	1.9	29.34	7.662
38	65	1.955	30.28	7.716
39	65	2.009	31.23	7.77
40	65	2.062	32.18	7.825
41	65	2.116	33.12	7.879
42	65	2.169	34.07	7.934
43	65	2.221	35.01	7.989
44	65	2.273	35.96	8.044
45	65	2.325	36.9	8.099
46	65	2.377	37.85	8.155
47	65	2.428	38.79	8.21
48	65	2.479	39.73	8.266
49	65	2.529	40.68	8.322
50	65	2.579	41.62	8.378

Dry Bulb Temp. (C)	Relative Humidity (%)	Beta	Dew point Temp. (C)	DEF Temp.(C)
25	70	1.289	19.15	5.846
26	70	1.348	20.11	5.889
27	70	1.407	21.07	5.933
28	70	1.466	22.02	5.976
29	70	1.524	22.98	6.02
30	70	1.582	23.94	6.063
31	70	1.639	24.89	6.107
32	70	1.696	25.85	6.151
33	70	1.752	26.8	6.196
34	70	1.808	27.76	6.24
35	70	1.864	28.72	6.285
36	70	1.919	29.67	6.329
37	70	1.974	30.63	6.374
38	70	2.029	31.58	6.419
39	70	2.083	32.54	6.464
40	70	2.136	33.49	6.51
41	70	2.19	34.44	6.555
42	70	2.243	35.4	6.601
43	70	2.295	36.35	6.646
44	70	2.348	37.31	6.692
45	70	2.399	38.26	6.739
46	70	2.451	39.22	6.785
47	70	2.502	40.17	6.831
48	70	2.553	41.12	6.878
49	70	2.603	42.08	6.924
50	70	2.654	43.03	6.971

Table 6: The amount of water present in 1m3in different temperature and different RH

Dry Bulb Temp. (C)	Relative Humidity (%)	Beta	Dew point Temp. (C)	DEF Temp.(C)
25	75	1.358	20.26	4.735
26	75	1.417	21.23	4.77
27	75	1.476	22.19	4.805
28	75	1.535	23.16	4.841
29	75	1.593	24.12	4.876
30	75	1.651	25.09	4.912
31	75	1.708	26.05	4.947
32	75	1.765	27.02	4.983
33	75	1.821	27.98	5.019
34	75	1.877	28.95	5.055
35	75	1.933	29.91	5.091
36	75	1.988	30.87	5.127
37	75	2.043	31.84	5.164
38	75	2.098	32.8	5.2
39	75	2.152	33.76	5.237
40	75	2.205	34.73	5.274
41	75	2.259	35.69	5.311
42	75	2.312	36.65	5.348
43	75	2.364	37.61	5.385
44	75	2.417	38.58	5.422
45	75	2.468	39.54	5.46
46	75	2.52	40.5	5.497
47	75	2.571	41.47	5.535
48	75	2.622	42.43	5.573
49	75	2.672	43.39	5.611
50	75	2.723	44.35	5.649

Dry Bulb Temp. (C)	Relative Humidity (%)	Beta	Dew point Temp. (C)	DEF Temp.(C)
25	80	1.422	21.31	3.687
26	80	1.482	22.29	3.715
27	80	1.541	23.26	3.742
28	80	1.599	24.23	3.77
29	80	1.657	25.2	3.797
30	80	1.715	26.17	3.825
31	80	1.772	27.15	3.853
32	80	1.829	28.12	3.881
33	80	1.886	29.09	3.909
34	80	1.942	30.06	3.937
35	80	1.998	31.03	3.965
36	80	2.053	32.01	3.994
37	80	2.108	32.98	4.022
38	80	2.162	33.95	4.051
39	80	2.216	34.92	4.079
40	80	2.27	35.89	4.108
41	80	2.323	36.86	4.137
42	80	2.376	37.83	4.166
43	80	2.429	38.81	4.195
44	80	2.481	39.78	4.224
45	80	2.533	40.75	4.253
46	80	2.585	41.72	4.282
47	80	2.636	42.69	4.312
48	80	2.686	43.66	4.341
49	80	2.737	44.63	4.371
50	80	2.787	45.6	4.401

Dry Bulb Temp. (C)	Relative Humidity (%)	Beta	Dew point Temp. (C)	DEF Temp.(C)
25	85	1.483	22.3	2.696
26	85	1.542	23.28	2.716
27	85	1.601	24.26	2.736
28	85	1.66	25.24	2.756
29	85	1.718	26.22	2.776
30	85	1.776	27.2	2.797
31	85	1.833	28.18	2.817
32	85	1.89	29.16	2.837
33	85	1.946	30.14	2.858
34	85	2.002	31.12	2.878
35	85	2.058	32.1	2.899
36	85	2.113	33.08	2.92
37	85	2.168	34.06	2.941
38	85	2.223	35.04	2.962
39	85	2.277	36.02	2.983
40	85	2.331	37	3.004
41	85	2.384	37.98	3.025
42	85	2.437	38.95	3.046
43	85	2.49	39.93	3.067
44	85	2.542	40.91	3.089
45	85	2.594	41.89	3.11
46	85	2.645	42.87	3.131
47	85	2.696	43.85	3.153
48	85	2.747	44.83	3.175
49	85	2.798	45.8	3.196
50	85	2.848	46.78	3.218

Dry Bulb Temp. (C)	Relative Humidity (%)	Beta	Dew point Temp. (C)	DEF Temp.(C)
25	90	1.54	23.25	1.754
26	90	1.599	24.23	1.767
27	90	1.658	25.22	1.78
28	90	1.717	26.21	1.793
29	90	1.775	27.19	1.806
30	90	1.833	28.18	1.82
31	90	1.89	29.17	1.833
32	90	1.947	30.15	1.846
33	90	2.004	31.14	1.86
34	90	2.06	32.13	1.873
35	90	2.115	33.11	1.886
36	90	2.171	34.1	1.9
37	90	2.225	35.09	1.914
38	90	2.28	36.07	1.927
39	90	2.334	37.06	1.941
40	90	2.388	38.05	1.955
41	90	2.441	39.03	1.968
42	90	2.494	40.02	1.982
43	90	2.547	41	1.996
44	90	2.599	41.99	2.01
45	90	2.651	42.98	2.024
46	90	2.702	43.96	2.038
47	90	2.753	44.95	2.052
48	90	2.804	45.93	2.066
49	90	2.855	46.92	2.08
50	90	2.905	47.91	2.094

Dry Bulb Temp. (C)	Relative Humidity (%)	Beta	Dew point Temp. (C)	DEF Temp.(C)
25	95	1.594	24.14	0.857
26	95	1.653	25.14	0.863
27	95	1.712	26.13	0.869
28	95	1.771	27.12	0.876
29	95	1.829	28.12	0.882
30	95	1.887	29.11	0.889
31	95	1.944	30.1	0.895
32	95	2.001	31.1	0.902
33	95	2.058	32.09	0.908
34	95	2.114	33.09	0.915
35	95	2.169	34.08	0.922
36	95	2.225	35.07	0.928
37	95	2.28	36.07	0.935
38	95	2.334	37.06	0.942
39	95	2.388	38.05	0.948
40	95	2.442	39.05	0.955
41	95	2.495	40.04	0.962
42	95	2.548	41.03	0.968
43	95	2.601	42.02	0.975
44	95	2.653	43.02	0.982
45	95	2.705	44.01	0.989
46	95	2.756	45	0.996
47	95	2.808	46	1.003
48	95	2.858	46.99	1.009
49	95	2.909	47.98	1.016
50	95	2.959	48.98	1.023

Dry Bulb Temp. (C)	Relative Humidity (%)	Beta	Dew point Temp. (C)	DEF Temp.(C)
25	100	1.645	25	0
26	100	1.705	26	0
27	100	1.764	27	0
28	100	1.822	28	0
29	100	1.88	29	0
30	100	1.938	30	0
31	100	1.996	31	0
32	100	2.052	32	0
33	100	2.109	33	0
34	100	2.165	34	0
35	100	2.221	35	0
36	100	2.276	36	0
37	100	2.331	37	0
38	100	2.385	38	0
39	100	2.439	39	0
40	100	2.493	40	0
41	100	2.546	41	0
42	100	2.599	42	0
43	100	2.652	43	0
44	100	2.704	44	0
45	100	2.756	45	0
46	100	2.808	46	0
47	100	2.859	47	0
48	100	2.91	48	0
49	100	2.96	49	0
50	100	3.01	50	0

Temp.	Saturation Pressure Ps (bar)	Relative Humidity (RH %)	Partial Pressure of water-Pw (bar)	Humidity Ratio	Amount of water (L/m^3 air)
25	0.032	35	0.0112	0.006952148	6.952148
26	0.034	35	0.0119	0.007391821	7.391821
27	0.036	35	0.0126	0.007832109	7.832109
28	0.038	35	0.0133	0.008273014	8.273014
29	0.04	35	0.014	0.008714536	8.714536
30	0.042	35	0.0147	0.009156677	9.156677
31	0.045	35	0.01575	0.009821053	9.821053
32	0.048	35	0.0168	0.010486828	10.48683
33	0.05	35	0.0175	0.010931459	10.93146
34	0.053	35	0.01855	0.011599578	11.59958
35	0.056	35	0.0196	0.012269109	12.26911
36	0.059	35	0.02065	0.012940056	12.94006
37	0.063	35	0.02205	0.013836864	13.83686
38	0.066	35	0.0231	0.014511135	14.51113
39	0.07	35	0.0245	0.015412389	15.41239
40	0.074	35	0.0259	0.0163162	16.3162
41	0.078	35	0.0273	0.017222577	17.22258
42	0.082	35	0.0287	0.018131532	18.13153
43	0.087	35	0.03045	0.019271368	19.27137
44	0.091	35	0.03185	0.020186163	20.18616
45	0.096	35	0.0336	0.021333333	21.33333

Temp.	Saturation Pressure Ps (bar)	Relative Humidity (RH %)	Partial Pressure of water-Pw (bar)	Humidity Ratio	Amount of water (L/m^3 air)
25	0.032	40	0.0128	0.007958019	7.958019
26	0.034	40	0.0136	0.008462162	8.462162
27	0.036	40	0.0144	0.008967112	8.967112
28	0.038	40	0.0152	0.009472872	9.472872
29	0.04	40	0.016	0.009979443	9.979443
30	0.042	40	0.0168	0.010486828	10.48683
31	0.045	40	0.018	0.011249435	11.24943
32	0.048	40	0.0192	0.012013883	12.01388
33	0.05	40	0.02	0.012524541	12.52454
34	0.053	40	0.0212	0.013292072	13.29207
35	0.056	40	0.0224	0.014061462	14.06146
36	0.059	40	0.0236	0.014832719	14.83272
37	0.063	40	0.0252	0.015863974	15.86397
38	0.066	40	0.0264	0.016639611	16.63961
39	0.07	40	0.028	0.017676732	17.67673
40	0.074	40	0.0296	0.018717227	18.71723
41	0.078	40	0.0312	0.019761112	19.76111
42	0.082	40	0.0328	0.020808404	20.8084
43	0.087	40	0.0348	0.022122336	22.12234
44	0.091	40	0.0364	0.023177356	23.17736
45	0.096	40	0.0384	0.024501	24.501

Temp.	Saturation Pressure Ps (bar)	Relative Humidity (RH %)	Partial Pressure of water-Pw (bar)	Humidity Ratio	Amount of water (L/m^3 air)
25	0.032	45	0.0144	0.008967112	8.967112
26	0.034	45	0.0153	0.009536149	9.536149
27	0.036	45	0.0162	0.010106213	10.10621
28	0.038	45	0.0171	0.010677308	10.67731
29	0.04	45	0.018	0.011249435	11.24943
30	0.042	45	0.0189	0.011822598	11.8226
31	0.045	45	0.02025	0.01268429	12.68429
32	0.048	45	0.0216	0.013548329	13.54833
33	0.05	45	0.0225	0.014125662	14.12566
34	0.053	45	0.02385	0.014993633	14.99363
35	0.056	45	0.0252	0.015863974	15.86397
36	0.059	45	0.02655	0.016736698	16.7367
37	0.063	45	0.02835	0.017904051	17.90405
38	0.066	45	0.0297	0.01878237	18.78237
39	0.07	45	0.0315	0.019957219	19.95722
40	0.074	45	0.0333	0.021136385	21.13638
41	0.078	45	0.0351	0.02231989	22.31989
42	0.082	45	0.0369	0.023507758	23.50776
43	0.087	45	0.03915	0.024998768	24.99877
44	0.091	45	0.04095	0.026196544	26.19654
45	0.096	45	0.0432	0.027700015	27.70002

Temp.	Saturation Pressure Ps (bar)	Relative Humidity (RH %)	Partial Pressure of water-Pw (bar)	Humidity Ratio	Amount of water (L/m^3 air)
25	0.032	50	0.016	0.009979443	9.979443
26	0.034	50	0.017	0.010613802	10.6138
27	0.036	50	0.018	0.011249435	11.24943
28	0.038	50	0.019	0.011886346	11.88635
29	0.04	50	0.02	0.012524541	12.52454
30	0.042	50	0.021	0.013164021	13.16402
31	0.045	50	0.0225	0.014125662	14.12566
32	0.048	50	0.024	0.01509022	15.09022
33	0.05	50	0.025	0.015734885	15.73488
34	0.053	50	0.0265	0.016704332	16.70433
35	0.056	50	0.028	0.017676732	17.67673
36	0.059	50	0.0295	0.018652097	18.6521
37	0.063	50	0.0315	0.019957219	19.95722
38	0.066	50	0.033	0.020939556	20.93956
39	0.07	50	0.035	0.022254025	22.25403
40	0.074	50	0.037	0.02357388	23.57388
41	0.078	50	0.039	0.024899153	24.89915
42	0.082	50	0.041	0.026229879	26.22988
43	0.087	50	0.0435	0.027901005	27.90101
44	0.091	50	0.0455	0.029244123	29.24412
45	0.096	50	0.048	0.030930847	30.93085

Table 7: The amount of water present in 1m3in different temperature and different RH

Temp.	Saturation Pressure Ps (bar)	Relative Humidity (RH %)	Partial Pressure of water-Pw (bar)	Humidity Ratio	Amount of water (L/m^3 air)
25	0.032	55	0.0176	0.010995028	10.99503
26	0.034	55	0.0187	0.011695139	11.69514
27	0.036	55	0.0198	0.012396799	12.3968
28	0.038	55	0.0209	0.013100015	13.10002
29	0.04	55	0.022	0.013804792	13.80479
30	0.042	55	0.0231	0.014511135	14.51113
31	0.045	55	0.02475	0.015573596	15.5736
32	0.048	55	0.0264	0.016639611	16.63961
33	0.05	55	0.0275	0.01735227	17.35227
34	0.053	55	0.02915	0.018424246	18.42425
35	0.056	55	0.0308	0.019499822	19.49982
36	0.059	55	0.03245	0.020579017	20.57902
37	0.063	55	0.03465	0.022023605	22.02361
38	0.066	55	0.0363	0.023111316	23.11132
39	0.07	55	0.0385	0.024567325	24.56732
40	0.074	55	0.0407	0.026029921	26.02992
41	0.078	55	0.0429	0.02749915	27.49915
42	0.082	55	0.0451	0.028975056	28.97506
43	0.087	55	0.04785	0.030829397	30.8294
44	0.091	55	0.05005	0.032320494	32.32049
45	0.096	55	0.0528	0.034193972	34.19397

Temp.	Saturation Pressure Ps (bar)	Relative Humidity (RH %)	Partial Pressure of water-Pw (bar)	Humidity Ratio	Amount of water (L/m^3 air)
25	0.032	60	0.0192	0.012013883	12.01388
26	0.034	60	0.0204	0.012780178	12.78018
27	0.036	60	0.0216	0.013548329	13.54833
28	0.038	60	0.0228	0.01431834	14.31834
29	0.04	60	0.024	0.01509022	15.09022
30	0.042	60	0.0252	0.015863974	15.86397
31	0.045	60	0.027	0.017028137	17.02814
32	0.048	60	0.0288	0.018196556	18.19656
33	0.05	60	0.03	0.018977879	18.97788
34	0.053	60	0.0318	0.020153446	20.15345
35	0.056	60	0.0336	0.021333333	21.33333
36	0.059	60	0.0354	0.022517564	22.51756
37	0.063	60	0.0378	0.024103337	24.10334
38	0.066	60	0.0396	0.025297797	25.2978
39	0.07	60	0.042	0.026897297	26.8973
40	0.074	60	0.0444	0.028504722	28.50472
41	0.078	60	0.0468	0.03012013	30.12013
42	0.082	60	0.0492	0.031743582	31.74358
43	0.087	60	0.0522	0.033784298	33.7843
44	0.091	60	0.0546	0.035426068	35.42607
45	0.096	60	0.0576	0.037489876	37.48988

Temp.	Saturation Pressure Ps (bar)	Relative Humidity (RH %)	Partial Pressure of water-Pw (bar)	Humidity Ratio	Amount of water (L/m^3 air)
25	0.032	65	0.0208	0.013036022	13.03602
26	0.034	65	0.0221	0.01386894	13.86894
27	0.036	65	0.0234	0.014704046	14.70405
28	0.038	65	0.0247	0.015541348	15.54135
29	0.04	65	0.026	0.016380856	16.38086
30	0.042	65	0.0273	0.017222577	17.22258
31	0.045	65	0.02925	0.018489329	18.48933
32	0.048	65	0.0312	0.019761112	19.76111
33	0.05	65	0.0325	0.020611777	20.61178
34	0.053	65	0.03445	0.021892011	21.89201
35	0.056	65	0.0364	0.023177356	23.17736
36	0.059	65	0.03835	0.024467843	24.46784
37	0.063	65	0.04095	0.026196544	26.19654
38	0.066	65	0.0429	0.02749915	27.49915
39	0.07	65	0.0455	0.029244123	29.24412
40	0.074	65	0.0481	0.030998498	30.9985
41	0.078	65	0.0507	0.03276235	32.76235
42	0.082	65	0.0533	0.034535757	34.53576
43	0.087	65	0.05655	0.036766071	36.76607
44	0.091	65	0.05915	0.038561262	38.56126
45	0.096	65	0.0624	0.040819057	40.81906

Temp.	Saturation Pressure Ps (bar)	Relative Humidity (RH %)	Partial Pressure of water-Pw (bar)	Humidity Ratio	Amount of water (L/m^3 air)
25	0.032	70	0.0224	0.014061462	14.06146
26	0.034	70	0.0238	0.014961443	14.96144
27	0.036	70	0.0252	0.015863974	15.86397
28	0.038	70	0.0266	0.016769067	16.76907
29	0.04	70	0.028	0.017676732	17.67673
30	0.042	70	0.0294	0.01858698	18.58698
31	0.045	70	0.0315	0.019957219	19.95722
32	0.048	70	0.0336	0.021333333	21.33333
33	0.05	70	0.035	0.022254025	22.25403
34	0.053	70	0.0371	0.023640014	23.64001
35	0.056	70	0.0392	0.02503198	25.03198
36	0.059	70	0.0413	0.02642996	26.42996
37	0.063	70	0.0441	0.028303359	28.30336
38	0.066	70	0.0462	0.029715527	29.71553
39	0.07	70	0.049	0.031607985	31.60799
40	0.074	70	0.0518	0.033511467	33.51147
41	0.078	70	0.0546	0.035426068	35.42607
42	0.082	70	0.0574	0.037351886	37.35189
43	0.087	70	0.0609	0.039775083	39.77508
44	0.091	70	0.0637	0.041726502	41.7265
45	0.096	70	0.0672	0.04418202	44.18202

Table 8: The amount of water present in 1m3in different temperature and different RH

Temp.	Saturation Pressure Ps (bar)	Relative Humidity (RH %)	Partial Pressure of water-Pw (bar)	Humidity Ratio	Amount of water (L/m^3 air)
25	0.032	75	0.024	0.01509022	15.09022
26	0.034	75	0.0255	0.016057707	16.05771
27	0.036	75	0.027	0.017028137	17.02814
28	0.038	75	0.0285	0.018001523	18.00152
29	0.04	75	0.03	0.018977879	18.97788
30	0.042	75	0.0315	0.019957219	19.95722
31	0.045	75	0.03375	0.021431853	21.43185
32	0.048	75	0.036	0.022913277	22.91328
33	0.05	75	0.0375	0.023904689	23.90469
34	0.053	75	0.03975	0.025397535	25.39753
35	0.056	75	0.042	0.026897297	26.8973
36	0.059	75	0.04425	0.028404025	28.40402
37	0.063	75	0.04725	0.030423913	30.42391
38	0.066	75	0.0495	0.031947082	31.94708
39	0.07	75	0.0525	0.033989071	33.98907
40	0.074	75	0.0555	0.036043853	36.04385
41	0.078	75	0.0585	0.038111548	38.11155
42	0.082	75	0.0615	0.040192277	40.19228
43	0.087	75	0.06525	0.042811709	42.81171
44	0.091	75	0.06825	0.044922222	44.92222
45	0.096	75	0.072	0.047579283	47.57928

Temp.	Saturation Pressure Ps (bar)	Relative Humidity (RH %)	Partial Pressure of water-Pw (bar)	Humidity Ratio	Amount of water (L/m^3 air)
25	0.032	80	0.0256	0.016122311	16.12231
26	0.034	80	0.0272	0.017157751	17.15775
27	0.036	80	0.0288	0.018196556	18.19656
28	0.038	80	0.0304	0.019238744	19.23874
29	0.04	80	0.032	0.020284331	20.28433
30	0.042	80	0.0336	0.021333333	21.33333
31	0.045	80	0.036	0.022913277	22.91328
32	0.048	80	0.0384	0.024501	24.501
33	0.05	80	0.04	0.025563833	25.56383
34	0.053	80	0.0424	0.02716465	27.16465
35	0.056	80	0.0448	0.028773401	28.7734
36	0.059	80	0.0472	0.030390145	30.39015
37	0.063	80	0.0504	0.032558342	32.55834
38	0.066	80	0.0528	0.034193972	34.19397
39	0.07	80	0.056	0.036387569	36.38757
40	0.074	80	0.0592	0.038595881	38.59588
41	0.078	80	0.0624	0.040819057	40.81906
42	0.082	80	0.0656	0.043057247	43.05725
43	0.087	80	0.0696	0.045876331	45.87633
44	0.091	80	0.0728	0.048148865	48.14886
45	0.096	80	0.0768	0.051011373	51.01137

Temp.	Saturation Pressure Ps (bar)	Relative Humidity (RH %)	Partial Pressure of water-Pw (bar)	Humidity Ratio	Amount of water (L/m^3 air)
25	0.032	85	0.0272	0.017157751	17.15775
26	0.034	85	0.0289	0.018261594	18.26159
27	0.036	85	0.0306	0.019369257	19.36926
28	0.038	85	0.0323	0.020480758	20.48076
29	0.04	85	0.034	0.021596119	21.59612
30	0.042	85	0.0357	0.02271536	22.71536
31	0.045	85	0.03825	0.024401538	24.40154
32	0.048	85	0.0408	0.02609656	26.09656
33	0.05	85	0.0425	0.027231522	27.23152
34	0.053	85	0.04505	0.028941438	28.94144
35	0.056	85	0.0476	0.030660384	30.66038
36	0.059	85	0.05015	0.032388433	32.38843
37	0.063	85	0.05355	0.034706783	34.70678
38	0.066	85	0.0561	0.036456355	36.45635
39	0.07	85	0.0595	0.03880367	38.80367
40	0.074	85	0.0629	0.04116778	41.16778
41	0.078	85	0.0663	0.043548867	43.54887
42	0.082	85	0.0697	0.045947115	45.94711
43	0.087	85	0.07395	0.048969339	48.96934
44	0.091	85	0.07735	0.051406881	51.40688
45	0.096	85	0.0816	0.054478828	54.47883

Temp.	Saturation Pressure Ps (bar)	Relative Humidity (RH %)	Partial Pressure of water-Pw (bar)	Humidity Ratio	Amount of water (L/m^3 air)
25	0.032	90	0.0288	0.018196556	18.19656
26	0.034	90	0.0306	0.019369257	19.36926
27	0.036	90	0.0324	0.020546261	20.54626
28	0.038	90	0.0342	0.021727593	21.72759
29	0.04	90	0.036	0.022913277	22.91328
30	0.042	90	0.0378	0.024103337	24.10334
31	0.045	90	0.0405	0.025896685	25.89668
32	0.048	90	0.0432	0.027700015	27.70002
33	0.05	90	0.045	0.028907823	28.90782
34	0.053	90	0.0477	0.030727979	30.72798
35	0.056	90	0.0504	0.032558342	32.55834
36	0.059	90	0.0531	0.034399	34.399
37	0.063	90	0.0567	0.036869374	36.86937
38	0.066	90	0.0594	0.038734392	38.73439
39	0.07	90	0.063	0.041237569	41.23757
40	0.074	90	0.0666	0.043759785	43.75978
41	0.078	90	0.0702	0.046301257	46.30126
42	0.082	90	0.0738	0.048862207	48.86221
43	0.087	90	0.0783	0.052091128	52.09113
44	0.091	90	0.0819	0.054696731	54.69673
45	0.096	90	0.0864	0.057982198	57.9822

Temp.	Saturation Pressure Ps (bar)	Relative Humidity (RH %)	Partial Pressure of water-Pw (bar)	Humidity Ratio	Amount of water (L/m^3 air)
25	0.032	95	0.0304	0.019238744	19.23874
26	0.034	95	0.0323	0.020480758	20.48076
27	0.036	95	0.0342	0.021727593	21.72759
28	0.038	95	0.0361	0.022979276	22.97928
29	0.04	95	0.038	0.024235837	24.23584
30	0.042	95	0.0399	0.025497303	25.4973
31	0.045	95	0.04275	0.027398764	27.39876
32	0.048	95	0.0456	0.029311425	29.31142
33	0.05	95	0.0475	0.030592804	30.5928
34	0.053	95	0.05035	0.032524354	32.52435
35	0.056	95	0.0532	0.034467371	34.46737
36	0.059	95	0.05605	0.03642196	36.42196
37	0.063	95	0.05985	0.039046256	39.04626
38	0.066	95	0.0627	0.041028247	41.02825
39	0.07	95	0.0665	0.043689464	43.68946
40	0.074	95	0.0703	0.04637213	46.37213
41	0.078	95	0.0741	0.049076505	49.07651
42	0.082	95	0.0779	0.051802855	51.80285
43	0.087	95	0.08265	0.055242102	55.2421
44	0.091	95	0.08645	0.058018882	58.01888
45	0.096	95	0.0912	0.061522043	61.52204

Temp.	Saturation Pressure Ps (bar)	Relative Humidity (RH %)	Partial Pressure of water-Pw (bar)	Humidity Ratio	Amount of water (L/m^3 air)
25	0.032	100	0.032	0.020284331	20.28433
26	0.034	100	0.034	0.021596119	21.59612
27	0.036	100	0.036	0.022913277	22.91328
28	0.038	100	0.038	0.024235837	24.23584
29	0.04	100	0.04	0.025563833	25.56383
30	0.042	100	0.042	0.026897297	26.8973
31	0.045	100	0.045	0.028907823	28.90782
32	0.048	100	0.048	0.030930847	30.93085
33	0.05	100	0.05	0.03228653	32.28653
34	0.053	100	0.053	0.034330643	34.33064
35	0.056	100	0.056	0.036387569	36.38757
36	0.059	100	0.059	0.038457427	38.45743
37	0.063	100	0.063	0.041237569	41.23757
38	0.066	100	0.066	0.043338084	43.33808
39	0.07	100	0.07	0.046159555	46.15955
40	0.074	100	0.074	0.049005057	49.00506
41	0.078	100	0.078	0.0518749	51.8749
42	0.082	100	0.082	0.054769396	54.7694
43	0.087	100	0.087	0.058422672	58.42267
44	0.091	100	0.091	0.061373814	61.37381
45	0.096	100	0.096	0.065098937	65.09894

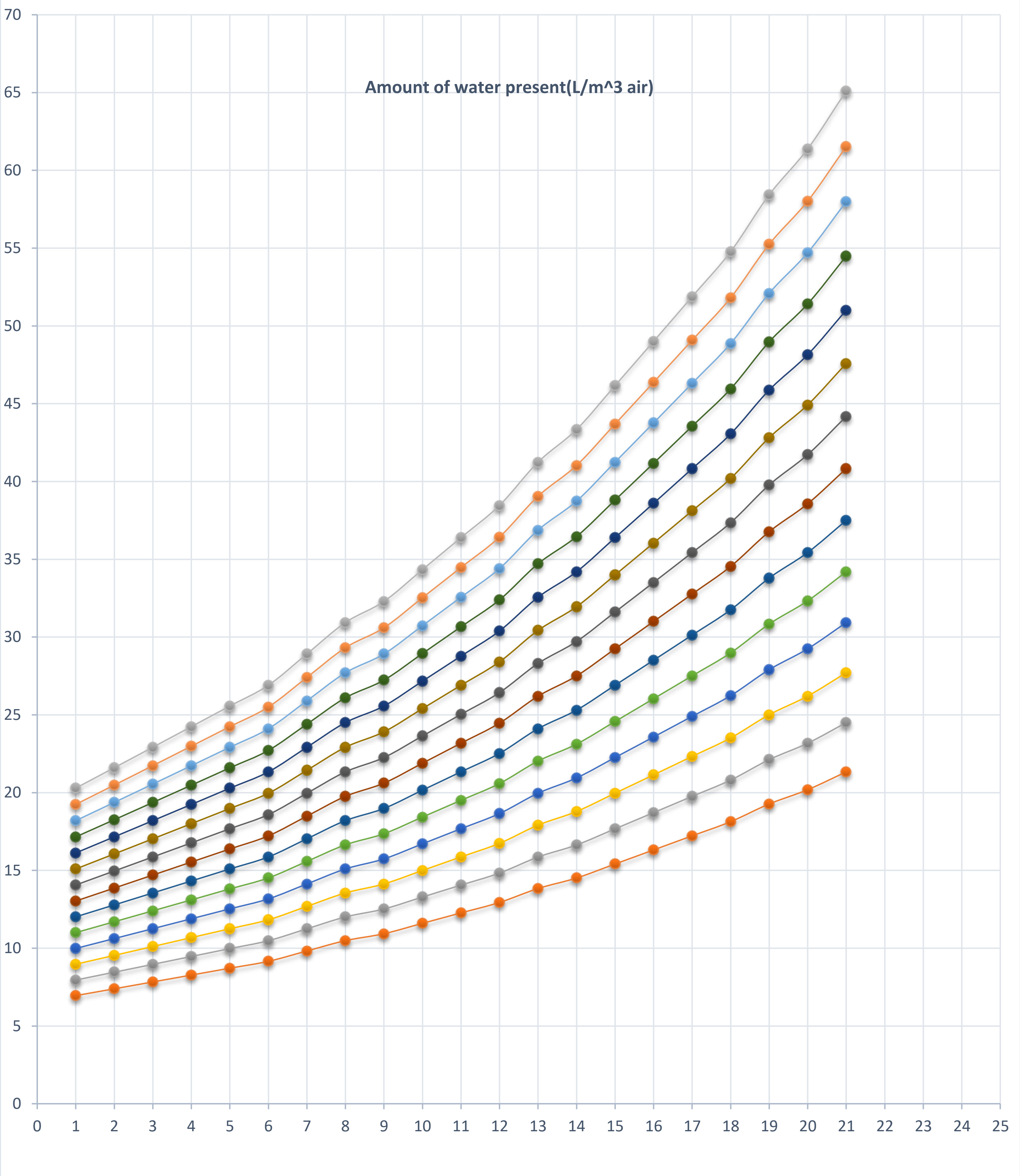


Figure 10: Amount of water present in 1m3 of air at different temperature and different RH

5. Conclusion

After analyzing all these aspects, it has been concluded that the thermoelectric refrigeration device can be used for the removal of moisture and water production. It has been further deduced that water production depends on the size of the thermoelectric device. Moreover, the best-operating regions are those that have high humidity and temperature. Lastly, solar energy can be sued as a power source for thermoelectric. However, all these aspects have been analyzed critically, and these aspects can be induced significantly for the water generation with the use of a refrigeration system.

Nomenclature

Exp	Experimental
ρ	Density.
v	Velocity vector.
Γ	Effective exchange coefficient of Ø.
$S_{Ø}$	Source rate per Unit volume.
C	Case
Vs	Supply velocity
P	the pressure of the gas in Pa
V	the volume of the gas in m3
m	the mass of the gas in Kg
R	a constant of proportionality
T	the absolute temperature of the gas in K
P_v	the partial pressure of water vapor in saturated air
P_{sw}	saturated pressure of vapor corresponding to wet bulb temperature from steam table
P_b	barometric pressure
t_w	wet bulb temperature
t_d	dry bulb temperature

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