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The Collection and Storage of Thermal Energy Using Locally Manufactured Solar Pond within Six Months (From August 2015 until January 2016)

[1] Dr. Yousef Al khateeb, [2] Somar Mahmoud Sudan

[1] Lecturer; Department of Chemistry, Faculty of Sciences, Tishreen University, Lattakia, Syria
[2] Postgraduate Student (Master Degree), Department of Chemistry, Faculty of Sciences, Tishreen University, Lattakia, Syria

Abstract: **According to the importance of economic solar ponds in domestic and industrial daily practical applications and its international widespread, this created the basis of an experimental study on a prismatic solar pond. It is internally painted in black with a surface measurement of ($1m^2$) and a lower measurement of ($0.42m^2$) and 1m deep. It constitutes four levels of gradual salinity separated by transparent glassy tablets /home glass/ of (6mm) thickness. On its lower level, a black solid mass is placed (black volcanic stones of equal dimensions; almost around 1cm). Upon studying the temperature and the stored thermal amounts of via subsidiary time every day from 9 am until 5 pm, the average rate of stored thermal amount each hour calculated according to the following equation: ($Q = m.C_p.\Delta T$) during six months (August 2015 until January 2016) was: 11661.482 KJ, 11616.498 KJ, 6671.280 KJ, 5915.907 KJ, 2236.467 KJ, 7703.131 KJ respectively.**

Keywords: **salinity gradient solar pond, the collection of thermal energy, the storage of thermal energy.**

I. INTRODUCTION

Energy is an important pillar of global economic and social development. Modern societies are influenced by the great development of science and technology, as well as industrialization. This has led to a radical change in the way we live. Nevertheless, there is also a dark side to this development: the depletion of traditional energy resources (oil, natural gas, coal) over a long period of time, Conventional fuel [1]. With the rise in the price of world crude oil, the increase in the impact of global warming and the limited life span of fossil fuels, renewable energies had to be used to achieve a secure and promising future for all humanity. Many scientists have done much research to develop renewable energy technology [3].

The world is leading strategic directions as renewable energy sources: solar energy, wind power, waterpower, atomic energy, bioenergy ... etc [4]. Solar energy is an important resource that can directly contribute to improving the quality of life on earth, if properly harnessed. The sun shines with energy at a rate of 3.85×10^{23}kw, of which about 1.72×10^{14}kw reaches the earth. The thermal flow of the solar energy in the outer atmosphere is about 1.38kw per square meter. , While the heat reaching the surface of the Earth at sea level is estimated at (990w) per square meter [6]. The solar pond is a typical example among the various solar systems that collect and store solar radiation for long periods of time. Moreover, it is one of the simplest direct methods for providing temperatures in the range of 50℃ to 120℃ [7]. The Solar Pool is a large solar collector with a large area where water is used as a conveyor medium for three basic factors: the synthesis of solar radiation energy and conversion into heat, storage of heat, and the transfer of heat energy out of the system for use in important home-based applications. The concept of the solar pond is not new. Research on solar ponds has been conducted in a number of countries since the beginning of the last century. Solar pools have been successfully designed and operated in Europe, the United States, Australia and some developing countries, often on a pilot basis in the past 50 years.

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Solar ponds have been shown to have the potential to collect solar thermal energy with an annual energy efficiency of up to 15 ~ 25%. This has made it interesting for many countries to supply sufficient heat in many areas in an environmentally safe manner [8].

II. EXPERIMENTAL

2.1 Research materials and methods:

Devices used:

A prism shaped pool composed of four inner layers, and digital thermometers with separate thread number 3.

2.2 Solutions and materials used: various saline solution concentrates (fresh water + sodium chloride NaCl commercial), translucent glass / glass house / number 3, solid body / black volcanic stone / transparent silicone type (Iranian, Belgian).

2.3 Salinity gradient solar pond (SGSP):

The solar pond consists of a three-tiered salinity gradient:

1. Upper convective zone (UCZ): The surface layer of the pond, a thin layer of fresh water with very low salinity at a depth of about 0.1 ~ 0.40 m, enjoys a low temperature very close to ambient temperature, Salinity 0%.

2. Non-convective zone (NCZ): The middle layer of the pond (salinity gradient), where salinity and temperature increase with increasing depth, separated between the upper and lower layers of the so-called labyrinthic layer, it is thicker and more than half the depth of the solar pond The thickness of this layer depends on the required temperature, the characteristics of solar and thermal transfer of water, the salinity ratio in this layer (6.08 ~ 9.80%).

3. Lower convective zone (LCZ) is a dense layer with high salinity. Its temperature is very high. Most of the solar energy is stored as heat. Here, salt concentration and temperature are almost constant. Thermal loss by convection, so called the stored layer of heat, the salinity ratio in this layer is 21.05% [9,10,11,12].

This experimental work includes the design of a porous solar pool with a surface area of m2 (1) and its bottom area (0.42 m2) with a depth of 1m also. It consists of four inner layers painted in black. A solid object is composed of black volcanic stones of equal dimensions (About 1Cm), the layers were separated from each other by translucent glass panels (6 mm thick household glass), installed in the middle of each layer of the pond (a separate digital thermometer) to measure the stored temperatures every hour for eight hours a day from 9 am to 5 pm.

This research studies the possibility of accumulating and storing thermal energy using a locally manufactured solar pool, heat-insulated from the surrounding medium / receiving solar radiation received only to the surface layer of the pond / depending on the increasing concentration of salt from 0% in the surface layer to 20 ~ 30% in the layer Lower is associated with an increase in stored temperatures, thus the amount of heat stored in each layer of pond). Salt is increasingly concentrated as well as temperature stored with increasing depth. Salt water cannot rise to the surface layer because the water above is less dense and has the lowest salt content between the layers of the pond.

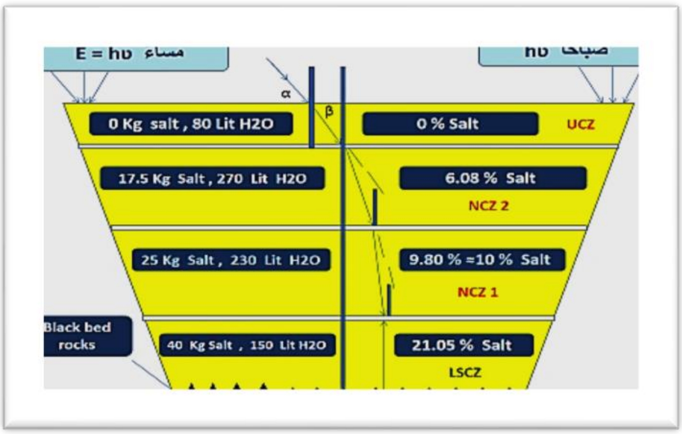

Fig.1. shows the studied solar pond layers and their content of water and salt

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2.4 Preparation of saline solutions:

According to reference studies, the NaCl is dissolved in water (370 gr / L) and therefore:

Each 1 liter of water is dissolved in

Each 100 liters of water dissolves in

X = (100 * 370) / 1 = 37000 gr = 37 Kgr.

Therefore:

Each 1370 gr solution contains 370 g NaCl

Each 100 gr solution contains Y gr NaCl

Y = (100 * 370) / 1370 = 27%

For a saturated solution, the percentage is taken as follows (73% water + 27% sodium chloride salt).

Bottom layer:

40 Kgr sodium chloride NaCl decayed in 150 lit water = (190 Kgr solution).

40 Kgr sodium chloride NaCl decomposed in 190 Kgr solution

X gr Sodium chloride NaCl decayed in 100 Kgr solution

The percentage (21.05%) is taken in this layer instead of (27%) for fear of reaching above saturation when the temperature drops at night.

Second layer (first medium):

25 Kgr sodium chloride NaCl decayed in 230 lit water = 255 Kgr (solution).

25 Kgr NaCl dissolved in 255 Kgr solution

Y Kgr sodium chloride NaCl decomposed in 100 Kgr solution

Y = (25 * 100) / 255 = 9.80% ≈ 10%

Third layer (second medium):

17.5 Kgr Sodium chloride NaCl decayed in 270 lit water = (287.5 Kgr solution).

17.5 Kgr sodium chloride NaCl decomposed in 287.5 Kgr solution

Z Kgr sodium chloride NaCl decomposed in 100 Kgr solution

Z = (17.5 * 100) / 287.5 = 6.08%

The fourth layer (surface): fresh water is taken only about 80 liters.

2.5 Calculation of specific thermal capacities:

Table1: shows the typical values of the predicted caloric loads of NaCl solution at different concentrations and temperatures [13]

Solution number	Temperature (°C)	Concentration %	Specific heat capacity of NaCl solution (J/Kg.°C)
1	10	5	3965.07
2	20	10	3764.34
3	30	15	3583.60
4	40	20	3428.22
5	50	25	3303.84
6	60	28	3247.45
7	70	29	3232.99
8	80	30	3219.94

Thus, the specific thermal capacities for each layer of pond are calculated as follows:

Bottom layer: Cp = 3366.03 / (4.18 * 1000) = 0.80 Cal / gr.℃

Where 3366.03 is the average value of: 3366.03 = 2 ((3428.22 + 3303.84)

This corresponds to the percentage X = (100 * 40) / 190 = 21.05%

Second layer (first medium): Cp = 3673.97 / (4.18 * 1000) = 0.87 Cal / gr.℃

With an average value of 3673.97 due to: (3764.34 + 3583.60) / 2 = 3673.97

This corresponds to the percentage Y = (100 * 25) / 255 = 9.80% ≈ 10%

Which is the closest value to 11.5%.

Third layer (second medium): Cp = 3864.705 / (4.18 * 1000) = 0.92 Cal / gr.℃

Where 3864.70 is an intermediate value due to:

(3965.07 + 3764.34) / 2 = 3864.705

This corresponds to the percentage: Z = (100 * 17.5) / 287.5 = 6.08%

Fourth Layer: For fresh water, the value Cp = 1 Cal / gr.℃.

The amount of heat stored in each layer of salinity gradient solar pond was calculated using equation: $\mathbf{Q = m. C_P . \Delta T}$

Whereas;

Q: the amount of heat (Calorie).

m: the mass of saline solution in each layer (gr).

Cp: Specific heat capacity (Cal / gr.℃).

ΔT: difference between temperature that recorded in the studied layer and the surrounding medium at the measurement hour (℃).

III. RESULTS AND DISCUSSION

The average rates of recorded temperatures as well as the amount of heat stored were calculated as follows:

3.1. Temperature recorded and the amount of heat stored in each layer of salinity gradient solar pond in August 2015:

Tables 2 and 3 present average rates of recorded temperatures and corresponding stored temperatures in each layer of pond in August 2015. We observe that the average rates of temperatures recorded per hour during the days of August 2015 increase with increasing time to reach semi-constant values at peak solar radiation times and then diminish slightly at the last two hours of measurement due to the low intensity of solar radiation received on the pond surface.

Table (3) shows that the mean values of the temperature levels stored in each layer of the studied solar pond increase with increasing time. This increase is of great value at peak times of solar radiation as the relationship between the recorded temperature and the stored temperature is the same. The highest values of the amount of heat stored in the bottom layer, which reached 15438.07 KJ at 14:00, were shown by the graphic curve in Fig2.

Table2: Average temperature of the recorded temperature as a measure of time in each layer of pond in August 2015 from 9 am to 5 pm.

Ambient temperature T (°C)	Recorded temperature in the surface layer T4 (°C)	Recorded temperatures in the second middle class T3 (℃)	Recorded temperatures in the first middle class T2 (°C)	Recorded temperatures in the bottom layer T1 (°C)	Measurement time t (h)
32.72	33.04	34.86	35.52	38.27	9
32.72	33.58	35.77	37.71	43.00	10
32.72	33.92	37.23	40.02	47.81	11
32.72	34.13	38.68	41.67	52.13	12
32.72	35.60	38.94	43.20	56.09	13
32.72	36.48	39.85	43.80	57.22	14
32.72	36.25	39.70	43.74	56.50	15
32.72	35.87	39.42	43.66	55.27	16
32.72	35.32	38.81	42.98	53.81	17

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Table3: Average of the amount of heat stored as a measure of time in each layer of pond in August 2015 from 9 am to 5 pm

Amount of heat stored in the surface layer Q4 (KJ)	Amount of heat stored in the second middle class Q3 (KJ)	Amount of heat stored in the first middle class Q2 (KJ)	Amount of heat stored in the bottom layer Q1(KJ)	Measurement time t (h)
107.01	2366.00	2596.53	3523.36	9
287.58	3372.11	4627.39	6526.88	10
401.28	4986.30	6769.53	9588.16	11
471.50	6589.43	8299.63	12331.76	12
963.07	6876.89	9718.45	14716.07	13
1257.34	7882.99	10274.85	15438.07	14
1180.43	7717.15	10219.21	15104.24	15
1053.36	7407.58	10145.02	14324.48	16
869.44	6733.16	9514.43	13400.32	17

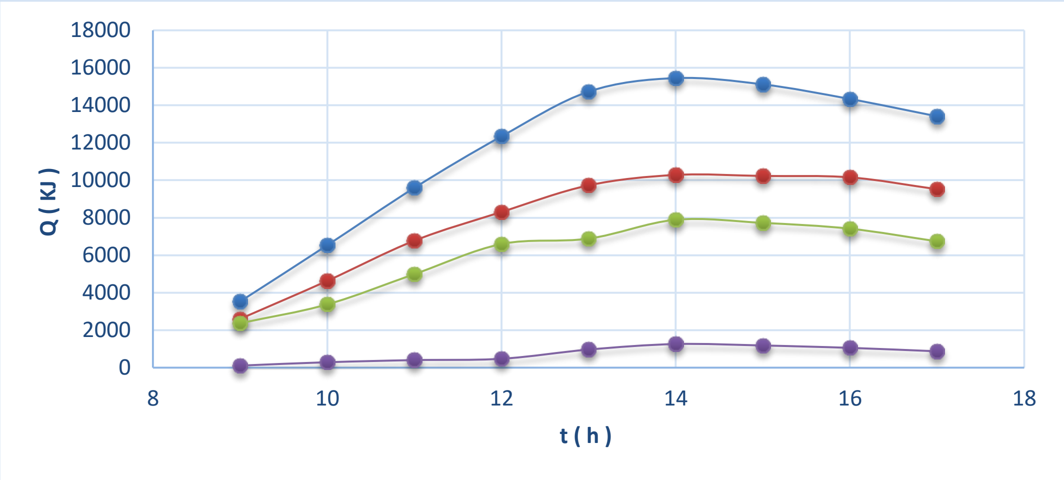

Fig.2.Amount of heat stored in each layer of (SGSP) in August 2015.

3.2. Temperature recorded and the amount of heat stored in each layer of salinity gradient solar pond in September 2015:

Tables 4 and 5 present average rates of recorded temperatures and corresponding stored temperatures in each layer of pond in September 2015. We observe that the average rates of temperatures recorded per hour during the days of September 2015 increase with increasing time to reach semi-constant values at peak solar radiation times and then diminish slightly at the last two hours of measurement due to the low intensity of solar radiation received on the pond surface.

Table 5 shows that the mean values of the temperature levels stored in each layer of the studied solar pond increase with increasing time. This increase is of great value at peak times of solar radiation as the relationship between the recorded temperature and the stored temperature is the same. The highest values of the amount of heat stored in the bottom layer, which reached 15058.03 KJ at 14:00, were shown by the graphic curve in Fig3.

Table4: Average temperature of the recorded temperature as a measure of time in each layer of pond in September 2015 from 9 am to 5 pm

Ambient temperature T (°C)	Recorded temperature in the surface layer T4 (°C)	Recorded temperatures in the second middle class T3 (°C)	Recorded temperatures in the first middle class T2 (°C)	Recorded temperatures in the bottom layer T1 (°C)	Measurement time t (h)
31.2	31.84	32.88	33.75	36.8	9
31.2	32.06	33.54	34.38	41.4	10

31.2	32.92	34.96	36.57	46.1	11
31.2	33.71	36.14	39.12	50.45	12
31.2	34.26	38.72	42.81	53.9	13
31.2	35.8	40.65	43.5	54.85	14
31.2	35.03	40.31	43.25	54.7	15
31.2	34.76	39.95	42.86	53.9	16
31.2	34.24	39.47	42.17	52.9	17

Table5: Average of the amount of heat stored as a measure of time in each layer of pond in September 2015 from 9 am to 5 pm

Amount of heat stored in the surface layer Q4 (KJ)	Amount of heat stored in the second middle class Q3 (KJ)	Amount of heat stored in the first middle class Q2 (KJ)	Amount of heat stored in the bottom layer Q1 (KJ)	Measurement time t (h)
214.016	1857.424	2364.699	3589.784	9
287.584	2587.127	2948.918	6512.44	10
575.168	4157.093	4979.778	9498.632	11
839.344	5461.713	7344.477	12262.45	12
1023.264	8314.187	10766.34	14454.44	13
1538.24	10448.01	11406.2	15058.03	14
1280.752	10072.11	11174.36	14962.73	15
1190.464	9674.087	10812.7	14390.9	16
1016.576	9143.394	10172.84	13819.08	17

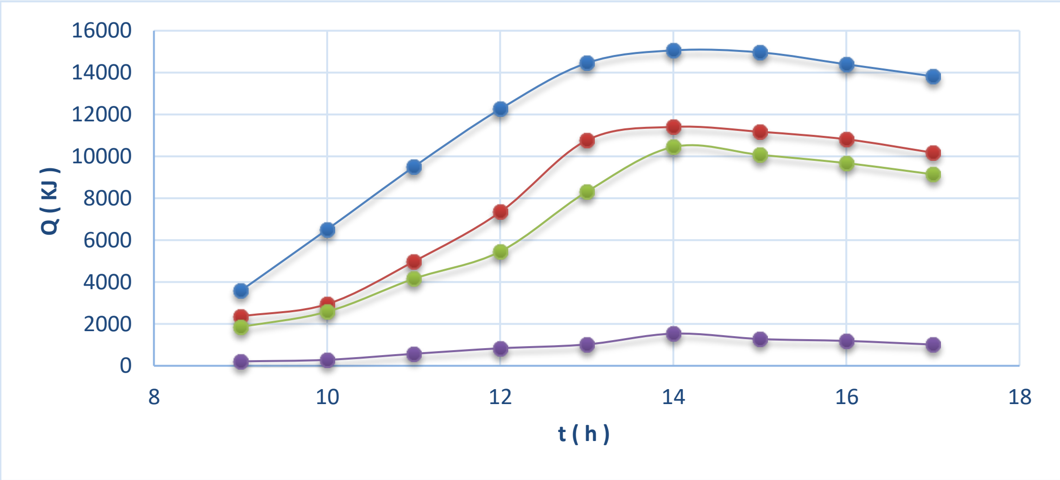

Fig.3.Amount of heat stored in each layer of (SGSP) in September 2015.

3.3. Temperature recorded and the amount of heat stored in each layer of salinity gradient solar pond in October 2015:

Tables 6 and 7 present the temperature of each layer of pond and the corresponding amount of heat recorded during the month of October.

We observe that the average temperature of hourly temperatures during the days of October 2015 increases with increasing time to reach semi-constant values at peak solar radiation times and then decreases slightly in the last two hours of measurement because of the low intensity of solar radiation received on the surface of the pond. Table 7 shows that the average values of the average quantities of heat stored in each layer of the studied solar pond increase with increasing time. This increase is of great value at peak times of the solar radiation as the relationship between the registered temperature and the stored temperature. The highest values of the amount of heat stored in the first middle layer, which reached 9421.703 KJ at 14:00, were recorded as a result of the appearance of turbidity, as shown by the graphic curve in Fig4.

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Table6: Average temperature of the recorded temperature as a measure of time in each layer of pond in October 2015 from 9 am to 5 pm

Ambient temperature T (°C)	Recorded temperature in the surface layer T4 (°C)	Recorded temperatures in the second middle class T3 (°C)	Recorded temperatures in the first middle class T2 (°C)	Recorded temperatures in the bottom layer T1 (°C)	Measurement time t (h)
28.11	28.61	29.25	30.22	31.44	9
28.11	29.82	31.17	32.8	34.44	10
28.11	30.25	32.5	34.61	37.72	11
28.11	30.97	32.89	34.96	40.27	12
28.11	31.15	34.77	36.58	41.33	13
28.11	32.4	35.6	38.27	41.22	14
28.11	30.86	34.93	37.48	40.88	15
28.11	30.48	34.27	36.5	40.33	16
28.11	29.67	33.81	36	39.94	17

Table7: Average of the amount of heat stored as a measure of time in each layer of pond in October 2015 from 9 am to 5 pm.

Amount of heat stored in the surface layer Q4 (KJ)	Amount of heat stored in the second middle class Q3 (KJ)	Amount of heat stored in the first middle class Q2 (KJ)	Amount of heat stored in the bottom layer Q1 (KJ)	Measurement time t (h)
167.2	1260.395	1956.672	2117.867	9
571.824	3383.166	4349.191	3953.351	10
715.616	4853.627	6027.664	6106.516	11
956.384	5284.815	6352.231	7730.213	12
1016.576	7363.362	7854.51	8400.871	13
1434.576	8281.018	9421.703	8330.275	14
919.6	7540.26	8689.11	8118.489	15
792.528	6810.557	7780.323	7765.511	16
521.664	6301.977	7316.657	7518.427	17

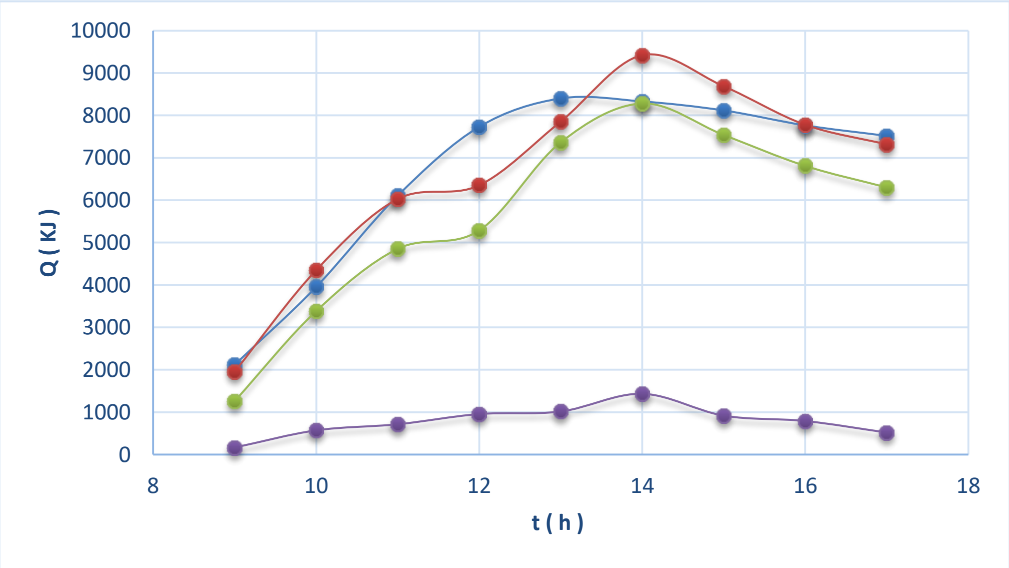

Fig.4.Amount of heat stored in each layer of (SGSP) in October 2015.

3.4. Temperature recorded and the amount of heat stored in each layer of salinity gradient solar pond in November 2015:

Tables 8 and 9 present the temperature of each layer of pond and the corresponding amount of heat recorded during the month of November.

We observe that the average temperature of hourly temperatures during the days of November 2015 increases as time increases to reach semi-constant values at peak solar radiation times and then decreases slightly at the last two measurement hours due to the low intensity of solar radiation received on the pond surface. Table 9 shows that the average values of the average quantities of heat stored in each layer of the studied solar pond increase with increasing time. This increase is of great value at peak times of solar radiation as the relationship between the recorded temperature and the stored temperature is the same. The highest temperature values stored in the first middle layer, which reached 9143.503 KJ at 13:00 as a result of the appearance of turbidity as shown by the graph curve in Fig5.

Table8: Average temperature of the recorded temperature as a measure of time in each layer of pond in November 2015 from 9 am to 5 pm.

Ambient temperature T (°C)	Recorded temperature in the surface layer T4 (°C)	Recorded temperatures in the second middle class T3 (°C)	Recorded temperatures in the first middle class T2 (°C)	Recorded temperatures in the bottom layer T1 (°C)	Measurement time t (h)
24.05	24.62	24.74	25.8	26.7	9
24.05	25.16	25.46	27.62	29.15	10
24.05	25.83	26.54	28.12	31.85	11
24.05	26.55	28.12	31.7	34.6	12
24.05	27.68	30.6	33.91	36.2	13
24.05	27.33	30.18	33.6	36.1	14
24.05	26.88	29.62	31.75	35.6	15
24.05	26.21	28.87	30.87	35.2	16
24.05	25.51	28.41	30.26	34.85	17

Table9: Average of the amount of heat stored as a measure of time in each layer of pond in November 2015 from 9 am to 5 pm.

Amount of heat stored in the surface layer Q4 (KJ)	Amount of heat stored in the second middle class Q3 (KJ)	Amount of heat stored in the first middle class Q2 (KJ)	Amount of heat stored in the bottom layer Q1 (KJ)	Measurement time t (h)
190.608	762.87	1622.832	1683.704	9
371.184	1558.91	3310.578	3240.336	10
595.232	2752.968	3774.245	4955.808	11
836	4499.832	7094.097	6703.048	12
1213.872	7241.745	9143.503	7719.624	13
1096.832	6777.389	8856.03	7656.088	14
946.352	6158.247	7140.464	7338.408	15
722.304	5329.04	6324.411	7084.264	16
488.224	4820.459	5758.737	6861.888	17

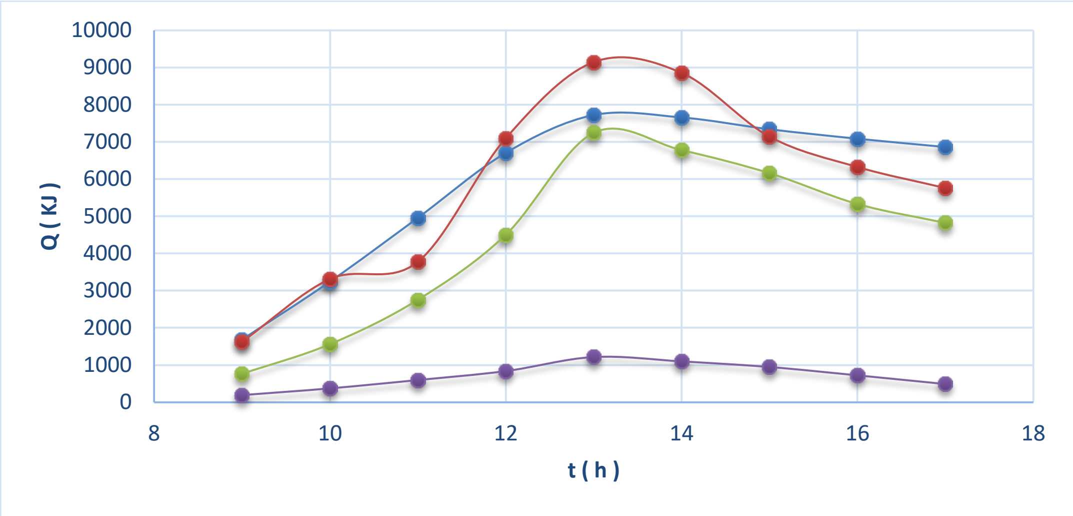

Fig.5.Amount of heat stored in each layer of (SGSP) in November 2015.

3.5. Temperature recorded and the amount of heat stored in each layer of salinity gradient solar pond in December 2015:

Tables 10 and 11 present the temperature of each layer of pond and the corresponding amount of heat recorded during the month of December.

We observe that the average temperature of hourly temperatures during the days of December 2015 increases with increasing time to reach semi-constant values at peak solar radiation times and then decreases slightly at the last two measurement hours due to the low intensity of solar radiation received on the pond surface. Table 11 shows that the average values of the average temperature levels stored in each layer of the studied solar pond increase with increasing time. This increase is of great value at peak times of solar radiation as the relationship between the registered temperature and the stored temperature is positive. The highest values for the amount of heat stored in the bottom layer, which reached KJ 3176.8 at 13:00, were shown by the graph curve in Fig6.

Table10: Average temperature of the recorded temperature as a measure of time in each layer of pond in December 2015 from 9 am to 5 pm.

Ambient temperature T (°C)	Recorded temperature in the surface layer T4 (°C)	Recorded temperatures in the second middle class T3 (°C)	Recorded temperatures in the first middle class T2 (°C)	Recorded temperatures in the bottom layer T1 (°C)	Measurement time t (h)
11.7	12.06	12.26	12.45	12.64	9
11.7	12.3	12.88	12.97	13.78	10
11.7	12.74	13.15	13.48	14.82	11
11.7	13.15	13.52	13.62	16.23	12
11.7	13.42	13.8	14.2	16.7	13
11.7	13.8	13.66	14.77	16.32	14
11.7	13.35	13.2	14.56	15.96	15
11.7	13.04	12.8	13.82	15.4	16
11.7	12.66	12.36	13.82	15.13	17

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Table11: Average of the amount of heat stored as a measure of time in each layer of pond in December 2015 from 9 am to 5 pm.

Amount of heat stored in the surface layer Q4 (KJ)	Amount of heat stored in the second middle class Q3 (KJ)	Amount of heat stored in the first middle class Q2 (KJ)	Amount of heat stored in the bottom layer Q1 (KJ)	Measurement time t (h)
120.384	619.141	695.499	597.238	9
200.64	1304.619	1177.71	1321.548	10
347.776	1603.134	1650.652	1982.323	11
484.88	2012.21	1780.479	2878.18	12
575.168	2321.781	2318.332	3176.8	13
702.24	2166.995	2846.912	2935.363	14
551.76	1655.53	2652.172	2706.633	15
448.096	1216.171	1965.945	2350.832	16
321.024	729.702	1965.945	2179.284	17

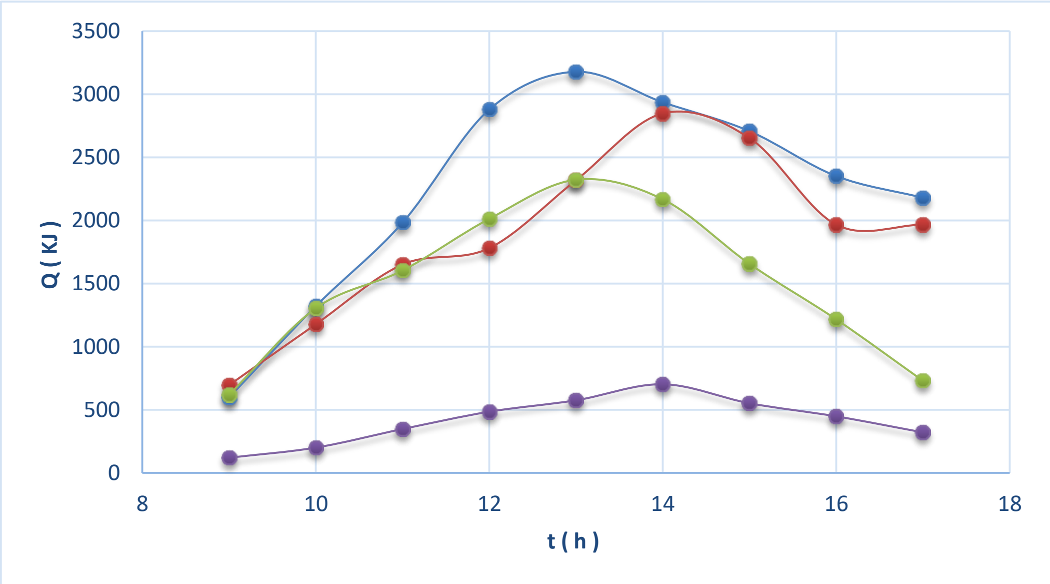

Fig.6.Amount of heat stored in each layer of (SGSP) in December 2015.

3.6. Temperature recorded and the amount of heat stored in each layer of salinity gradient solar pond in January 2016:

Tables 12 and 13 present the temperature of each layer of pond and the corresponding amount of heat recorded during the month of January.

We observe that the average temperature of hourly temperatures during the days of January 2016 increases with increasing time to reach semi-constant values at peak solar radiation times and then decreases slightly in the last two hours of measurement because of the low intensity of solar radiation coming to the surface of the pond. Table 13 shows that the average values of the average quantities of heat stored in each layer of the studied solar pond increase with increasing time. This increase is also significant in times of peak solar radiation. The relation between the recorded temperature and the stored temperature is positive. The highest temperature values stored in the bottom layer, which reached 9380.939 KJ at 12 noon, were shown by the graph curve in Fig7.

Table12: Average temperature of the recorded temperature as a measure of time in each layer of pond in January 2016 from 9 am to 5 pm

Ambient temperature T (°C)	Recorded temperature in the surface layer T4 (°C)	Recorded temperatures in the second middle class T3 (°C)	Recorded temperatures in the first middle class T2 (°C)	Recorded temperatures in the bottom layer T1 (°C)	Measurement time t (h)
13.14	13.5	14.46	15.38	17.14	9
13.14	14.18	15.71	19.65	21.33	10
13.14	14.86	16.28	20.42	25.38	11
13.14	15.34	17.4	21.17	27.904	12
13.14	16.71	17.98	21.76	27.809	13
13.14	16.9	18.64	22.53	27.476	14
13.14	16.58	18.08	21.88	27.238	15
13.14	16.13	17.81	21.64	26.571	16
13.14	15.94	17.39	20.31	26.523	17

Table13: Average of the amount of heat stored as a measure of time in each layer of pond in January 2016 from 9 am to 5 pm.

Amount of heat stored in the surface layer Q4 (KJ)	Amount of heat stored in the second middle class Q3 (KJ)	Amount of heat stored in the first middle class Q2 (KJ)	Amount of heat stored in the bottom layer Q1 (KJ)	Measurement time t (h)
120.384	1459.405	2077.226	2543.255	9
347.776	2841.418	6036.938	5203.598	10
575.168	3471.615	6750.984	7777.411	11
735.68	4709.899	7446.484	9380.939	12
1193.808	5351.152	7993.61	9320.095	13
1257.344	6080.855	8707.657	9108.52	14
1150.336	5461.713	8104.89	8957.305	15
999.856	5163.199	7882.331	8533.52	16
936.32	4698.843	6648.978	8503.537	17

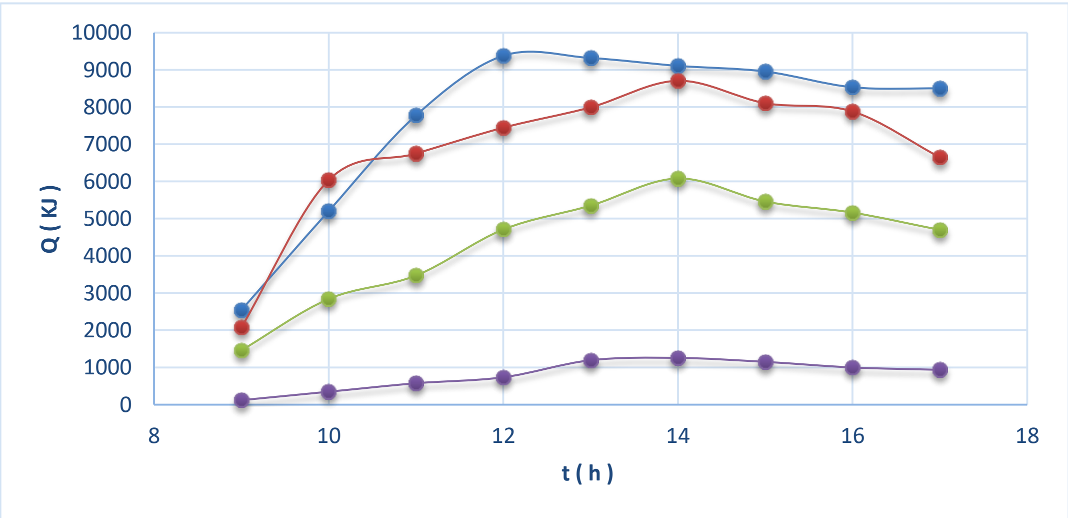

Fig.7.Amount of heat stored in each layer of (SGSP) in January 2016.

3.7. Recorded temperatures and the amount of heat stored in each layer of pond during six months:

Tables 14 and 15 present the temperatures and the quantities of heat stored in each layer within six months respectively from August 2015 to January 2016.

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Table 14: Average rates of temperature recorded in each layer of the pond and compared with ambient temperature during the six months (from August 2015 to January 2016).

Ambient temperature T (°C)	Recorded temperature in the surface layer T4 (°C)	Recorded temperatures in the second middle class T3 (°C)	Recorded temperatures in the first middle class T2 (°C)	Recorded temperatures in the bottom layer T1 (°C)	Measurement time t (month)
32.72	34.91	38.14	41.366	51.12	Aug. 2015
31.2	33.84	37.40	39.82	49.44	Sep. 2015
28.11	30.467	33.24	31.91	38.618	Oct. 2015
24.05	26.196	28.06	30.304	33.361	Nov. 2015
11.7	12.946	13.07	13.743	15.22	Dec. 2015
13.14	15.571	17.083	20.526	25.263	Jan. 2016

Table 15: Average rates of heat stored in each layer of pond during six months (from August 2015 to January 2016)

Amount of heat stored in the surface layer Q4 (KJ)	Amount of heat stored in the second middle class Q3 (KJ)	Amount of heat stored in the first middle class Q2 (KJ)	Amount of heat stored in the bottom layer Q1 (KJ)	Measurement time t (month)
732.334	5992.401	8018.337	11661.482	Aug. 2015
885.045	6857.238	7996.701	11616.498	Sep. 2015
788.440	5675.464	6638.673	6671.280	Oct. 2015
717.845	4433.496	5891.655	5915.907	Nov. 2015
416.885	1515.294	1676.411	2236.467	Dec. 2015
812.963	4359.788	6849.899	7703.131	Jan. 2016

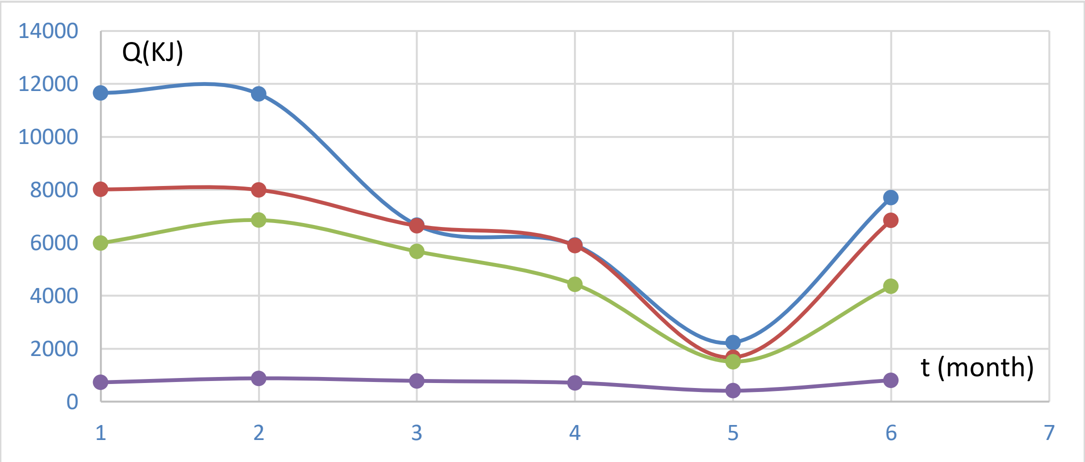

Fig.8. Average temperature values stored in time sequence Q = f (t), within six months (from August 2015 to July 2016)

From figure (2 to 8) and tables (2 to 15) respectively, we observe the increasing temperature values recorded and the amount of heat stored in each hour and layer as time increases. This increase is of great value at times of solar radiation (afternoon) this is due to the fact that when the beam travels from a less dense medium to a more intense medium, it breaks down closer to the regulator and thus the reflected radiation (the amount of heat stored) decreases in the denser medium, the amount of heat gradually from the upper layer to bottom layer.

Table 15 shows that the highest values of heat stored in the stored bottom layer were recorded for six months. This is due to the concentration of salt and the temperature increasing with increasing depth. Salt water cannot rise to the surface layer because the water above is less density and has the lowest salinity content between the layers of the pond, and that the heat cannot be transmitted within the solutions thermal currents because of the difference between the density of salt solutions

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on one hand and because of the presence of glass panels that separate the layers of the pond, and therefore notes that the temperatures recorded in the layer the surface is closest to ambient temperature, which in turn causes the value of the amount of heat stored in this layer to be very small compared to the other layers that follow.

IV. CONCLUSIONS

1 - The amount of heat stored in each layer of the pond increases with the times of the beginning of the day at 9 am, and peak at 14 and 15 pm every day.

2 - The amount of heat stored in each layer increases from the month of August during the year 2015, and begins to decline until the month of January of 2016.

3 - The study showed that the highest amount of stored heat was in the bottom layer stored for heat in the month of August of 2015, which amounted to 15438.07KJ.

4. The amount of stored heat increases as the layer depth increases with increased concentration.

5. The intensity of the incoming solar radiation decreases and therefore the stored temperature leads to a decrease in the amount of heat. This is manifested by the abnormality of some values as a result of the appearance of turbidity in the saline solutions that are composed of each layer of the solar pond.

V. RECOMMENDATIONS

1. Work to increase research towards alternative energies, including solar energy, and to study their effectiveness and economic feasibility, which ultimately lead to the service and progress of societies.

2. The solar pool is one of the technologies used to collect heat of the sun, which is a limited cost is very important in many countries of the world, so we recommend experimental studies using this technology to improve storage efficiency and increase productivity in domestic applications, agricultural and industrial.

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