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Contents

Introduction

Praise be to Allah, who has guided and enabled us to publish the eleventh issue of the ***Gharyan Journal of Technology***. We thank Him for this blessing. As we promised from the very beginning with the release of the first issue in 2016, we have continued our commitment to maintaining the journal's credibility by upholding academic integrity and relying on reviewers with sufficient expertise in their fields. This ensures that the works published in the journal are characterized by rigor and scientific methodology, without favoritism, bias, or leniency in publishing studies that lack scientific and research value. Although we receive a larger number of submissions, we publish only a limited number of research papers in each issue because many are declined by reviewers for not meeting scientific standards. We look forward to ensuring that the published studies contribute to offering proposals and developing effective solutions to the challenges faced by institutions such as companies, factories, hospitals, and other sectors.

Nations strive for progress and for attaining distinguished status through achieving growth, economic advancement, and a decent quality of life for their people. Scientific research is one of the most important means of reaching that noble goal. By employing research in innovative applications that serve humanity in general, this objective can be fulfilled. Developed countries allocate significant portions of their financial resources toward achieving this aim.

We fully recognize that working in peer-reviewed scientific journals is a demanding task, especially under the circumstances our country in particular—and the world in general—are experiencing. However, we accepted this challenge with full confidence that Allah will support us as we endeavor to present valuable work that benefits researchers, specialists, and interested readers. Our aim is for the journal to be one of the scientific platforms for researchers in a world witnessing an intense race in the realms of civilization, science, research, and technology. We strive diligently to carve out a worthy place for the journal, benefiting from the experiences of those who preceded us in this long path. With God's permission, we hope that upcoming issues will be of even higher quality and that our journal will achieve an impact factor that reflects the value of the research it publishes. What further strengthens our determination and confidence is that the ***Gharyan Journal of Technology*** is issued by a well-established academic institution more than thirty years old, distinguished by its graduates who have joined numerous institutions across the country and have presented a positive image of the educational institution that prepared them.

The eleventh issue of the ***Gharyan Journal of Technology*** contains numerous research papers and scientific articles characterized by creativity and diversity, contributed by researchers from various educational institutions.

The Editorial Board renews its welcome to all researchers and contributors wishing to participate with scientific papers and innovative research in your journal, the ***Gharyan Journal of Technology***, which seeks to achieve distinction among peer-reviewed scientific journals. We open the door to your suggestions, remarks, and constructive criticism, believing that such feedback is the best way to develop the journal, enhance its scientific value, and support its continuity.

The Editorial Board

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Modeling The performance Of Solar Stills Of The City Of Tripoli

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الخلاصة :

محور هذه الدراسة يتمركز على إمكانية محاكاة وعمل مقطر شمسي في ظل ظروف مناخية مختلفة لمدينة طرابلس, ليبيا و التي تمثل الفصول الأربعة من السنة , للحصول على إنتاجية عالية من الماء المقطر وفقا للظروف المناخية و القيم التصميمية. يلعب الموقع الجغرافي والظروف المناخية دورًا رئيسيًا في تحسين أداء جهاز التقطير الشمسي, الكفاءة الحرارية, السعة الإنتاجية. بالإضافة إلى التصميم الهندسي, البنية الداخلية للمادة والتي تدخل تحت دراسة علم المواد. في هذه الورقة تم تقديم دراسة تحليلية على مدى تأثير ظروف الإشعاع و درجة حرارة الجو المحيطة وسرعة الرياح على أداء المقطر الشمسي. الدراسة تتضمن نموذجا لحل ثلاثة معادلات تفاضلية للغطاء الزجاجي, وماء الحوض و بطانة الحوض بالنسبة للمقطر شمسي التقليدي مؤسسة على توازن الطاقة (Energy Balances) وذلك باستخدام رانج كوتا أربعة, باعتبار تأثير درجة حرارة الجو المحيطة و الإشعاع الشمسي المؤسس على نموذج آشري (ASHRAE Mode) .

حيث تم الحصول على النتائج باستخدام نموذج رياضي طُور باستعمال برمجة لغة فورتران95 للمحاكاة الرئيسية، لانتقال الحرارة والكتلة في المقطر الشمسي على أساس عرض مقدم في صورة أنماط و مخططات وجداول, توضح تغير مؤشرات الأداء مثل درجة حرارة الغطاء الزجاجي , ماء الحوض, بطانة الحوض, الكفاءة الحرارية, والإنتاجية الساعية واليومية تحت ظروف محيطة مختلفة درجة الحرارة المحيطة و الإشعاع الشمسي. أظهرت النتائج تحقيق أعلى كفاءات حرارية ساعية للأشهر الأربعة يناير، أبريل، يوليو، وأكتوبر:44 %، 49.7 %،69.5 %، و47.6 % على التوالي,. وبالمثل، بلغت إنتاجية جهاز التقطير التقليدي 0.537 لتر/م^{2}ساعة، 1.292 لتر/م^{2}ساعة، 1.303 لتر/م^{2}ساعة، و0.935 لتر/م^{2}ساعة, كقيمة قصوى خلال منتصف النهار لشهر يناير، وأبريل، ويوليو، وأكتوبر من العام على التوالي. ومع ذلك، بلغ إجمالي الإنتاجية من الساعة 08:00 صباحًا حتى الساعة 20:00 مساءً لأشهر يناير وأبريل ويوليو وأكتوبر 3.042 لتر/م^2/يوم، و8.621 لتر/م^2/يوم، و8.945 لتر/م^2/يوم، و5.664 لتر/م^2/يوم على التوالي. و كما يلاحظ أيضا من النتائج أن درجات الحرارة الأعلى لماء الحوض 48.23 م^o, 67.776 م^o, 71.032 م^o, 60.509 م^o لشهر يناير، وأبريل، ويوليو، وأكتوبر على التوالي, هذا وبشكل ملحوظ ذو أهمية كبيرة من حيث الطاقة الشمسية وما مدى الاستفادة من درجة حرارة تبخر الماء.

الكلمات المفتاحية : المقطر الشمسي التقليدي, الإشعاع الشمسي, الإنتاجية, إجمالي الإنتاجية اليومية, الكفاءة الحرارية.

Abstract:

The focus of this study is on the possibility of simulation on operating a Solar Still under different climatic conditions in Tripoli city-Libya, which represent the four seasons of the year, to obtain high-level production of distilled water according to the climatic conditions and design values of study. The geographical location and climatic conditions play major role in improving the performance of the Solar Still, thermal efficiency, and production capacity. In addition to the engineering design, the internal structure of the material, which falls under the study of Materials Science. In this paper, an analytical study is presented on the extent radiation conditions, ambient temperature, and wind speed affect the performance of the Solar Still. The study includes a model to solve three differential equations of the glass cover, the basin water and the basin liner for a conventional Solar Still based on the energy balances using Runge Kutta four, considering the effect of ambient temperature and solar radiation based on the ASHRAE Model.

The results were obtained using a mathematical model developed using Fortran 95 programming language for the main simulation of heat and mass transfer in the solar still based on a presentation presented in the form of graphs, patterns, and tables that illustrate the change in performance factors such as the temperature of the glass cover, the basin water, the basin liner, thermal efficiency, and hourly and daily productivity under different ambient conditions of ambient temperature and solar radiation. The results show that the highest hourly thermal efficiencies were achieved in the four months of January, April, July, and October: 44%, 49.7%, 69.5%, and 47.6%, respectively. Likewise, the productivity of the conventional distillation device was 0.537 L/m²/h, 1.292 L/m²/h, 1.303 L/m²/h, and 0.935 L/m²/h as the maximum values during mid-day for the different months of January, April, July, and October, respectively. However, the cumulative productivity from 8:00 a.m. to 20:00 p.m. in the months of January, April, July, and October were respectively 3.042 L/m²/day, 8.621 L/m²/day, 8.945 L/m²/day, and 5.664 L/m²/day. It is also noted from the results that the highest temperatures of the basin water were respectively 48.23 C^o, 67.776 C^o, 71.032 C^o, 60.509 C^o for January, April, July, and October. This was remarkably important in terms of Solar Energy on the extent of utilization of water evaporation temperature.

Key Words : conventional solar still ,solar radiation , hourly productivity, cumulative productivity ,thermal efficiency

Symbols	**Nomenclatures**	**Units**
A_b	Surface Area of solar still basin	m^2
A_g	Surface Area of solar still glass	m^2
A_w	Surface Area of solar still water	m^2
$C_{p,b}$	Specific heat capacity of the basin liner	J/kg °C
$C_{p,g}$	Specific heat capacity of the glass cover	J/kg °C
$C_{p,w}$	Specific heat capacity of the water mass	J/kg °C
$h_{e,wg}$	Evaporative heat transfer coefficient from water mass and glass cover	W/m^2 °C
h_{fg}	The latent heat of vaporization	*J/kg*
I_b	Direct solar radiation	W/m^2
I_d	rate at which energy is diffused on to sky (Isotropic Sky)	W/m^2
I_{tH}	rate at which the total radiation (direct plus diffuse) strikes the horizontal surface or ground in front of the wall	W/m^2
I_r	rate at which Energy reflected from ground and surroundings (diffuse reflection)	W/m^2
$IG_{t\beta}$	The total solar radiation on the inclined glass cover of the solar still	W/m^2
IG_{tH}	The total solar radiation on the inclined water and basin of the solar still	W/m^2
M_b	Basin mass	*Kg*
M_g	Glass cover mass	*Kg*
M_w	Water mass	*kg*
m_w	water vapor mass	$l/m^2.hr$
$q_{c,b-w}$	Convection heat transfer between basin liner and water mass	*W*
$q_{c,ga}$	Convection heat transfer between glass cover and ambient air	*W*
$q_{c,wg}$	Convection heat transfer within the solar still from water mass and glass cover	*W*

Symbols	Nomenclatures	Units
$q_{e,wg}$	Evaporation heat transfer within the solar still from water mass and glass cover	W
q_{loss}	Conduction heat transfer between basin liner and atmosphere	W
$q_{r,ga}$	Radiation heat transfer between glass cover and ambient	W
$q_{r,wg}$	Radiation heat transfer within the solar still from water mass and glass cover	W
T_a	Ambient Temperature	°C
T_b	Basin liner Temperature	°C
T_g	Glass cover Temperature	°C
T_w	Water Temperature	°C
N	The number of day in the year	--

Greek Letter Symbols:

Symbols	Nomenclatures	Units
α_b	Basin liner absorptivity	--
α_g	Glass cover absorptivity	--
ρ_g	reflectance of ground or horizontal surface	--
α_w	Water mass absorptivity	--
αs	solar altitude	degree
τ_g	glass transmittance	--
τ_w	water transmittance	--
τ_{dr}	droplets transmittance	--
ε_{eq}	effective diffusivity	--
ε_g	Transmissivity of the glass cover	--
ε_w	Transmissivity of the water mass	--
η_{th}	The instantaneous efficiency of a solar still	--

1.Introduction

Libya has recently been suffering from a severe shortage of potable water, where groundwater consisting 97% of the total potable water reserve, with depleting a large part of this reserve, there was an urgent need to estimate and search for permanent and renewable alternatives. In the way of utilizing future solutions, it was necessary to accelerate the implementation of seawater purification projects, brackish and sewage water recycling to support the needs of the population, industry, agriculture, and livestock by establishing drinking water desalination plants and distillation towers using traditional fuel from oil and gas or renewable energy from the sun and wind. Therefore, our research was on how to build to a Solar Still to purify water, taking advantage of the climatic conditions available in Libya. With the availability of renewable and sustainable energy such as the sun, the matter is highly relevant for Libya and other arid regions where freshwater scarcity is a major issue.

D. W. Medugu and L. G. Ndatuwong [1] in 2009 have obtained the experimental result of distillate of water from the constructed still. The productivity of distillate water corresponds favorably with the theoretical analysis. Their maxima taken place at 12:00 AM, where solar radiation intensity and the temperature of water inside the still are high, are 1.60 l/m^2hr and 1.5942 $l/m^2.hr$ for practical and computed values respectively.

Wissam H. Alawee [2] in 2015 presented an experimental study to improve the productivity of a conventional Solar Still. He constructed two Solar Stills, one with a conventional design and the other according to the proposed design. Both were tested from February to July 2009 under varying weather conditions in Basra, Iraq. Satisfactory results were obtained. The maximum value at 12:00 AM was 1.35 l/m^2hr for the conventional still and 1.45 $l/m^2/h$ for the proposed still. The daily productivity (cumulative productivity) were 9.40 $l/m^2/day$ and 11.00 $l/m^2/day$ to at 18: 00 for two Solar Stills, one with the conventional design and the other with the proposed design.

Abdelkader Bellila, Abd Elnaby Kabeel, M. El Hadi Attia, H. A. Dahab and M. A. Elazab [3] conducted a study in July 15, 2023 to determine the most effective energy storage materials within the water basin liner to for improving the performance of a conical solar distillation system (CSDS). The study reached the following major conclusions: firstly, was cumulative productivity for Stainless steel balls (CSD-SSB) achieved the highest water productivity at 9.45 liters/m^2/day, followed by glass balls (CSD-GB) at 8.75 liters/m^2/day, black gravel (CSD-BG) at 8.25 liters/m^2/day, and sandstone (CSD-SS) at 7.70 liters/m^2/day. The conventional system (CCSD) achieved the lowest productivity at 5.75 liters/m^2/day to at 18:00 PM.

Mokhtar Mohammed and Taha Janan Mourad [4] in 2021 reported a theoretical study of energy balance for all parts of a new design of solar concentration distiller using a parabolic concentrator with a half-cylinder basin. The methodology concentrates on solving the thermal collector's energy balance equations which components are the glass cover, the brackish water and half-cylinder absorber. Where productivity of distilled water, the largest amount was harvested between 11:22 AM to 14:22 PM where the solar radiation was at maximum and the maximum value of the productivity was 1.45 $kg/m^2.hr$ at mid-day.

1. MODELING OF SOLAR STILL

The conventional Solar Still system consists of the following main parts: a feeding water tank, a distillation basin with thermal insulation and a pipe network. The basin area of the solar still was 0.75 m2 (1.25 m × 0.60 m). Glass panel was used to cover the solar still from the top, and it was fixed at a 35° angle with the horizontal. Condensed water flowed down through glass cover into a collection canal and was stored in water storage bottle.

- **ASHRAE Clear Sky Model** (Global Solar Radiation))[5]

Total solar radiation incident on a non-vertical surface,

$$IG_t = IB + Id + Ir \tag{1}$$

$$IG_{t,\beta} = \left[max\left(\cos\theta_\beta, 0\right) + C \ \left(\frac{1+\cos\beta}{2}\right) + \rho_g \ \left(\frac{1-\cos\beta}{2}\right)(\sin\alpha_S + C)\right] \ Ib \tag{2}$$

For a horizontal surface

$$IG_{t,H} = \left[max(\cos\theta_H, 0) + C \ \left(\frac{1+\cos\beta}{2}\right)\right] \ Ib \tag{3}$$

Where C diffuse radiation factor can be calculated in eq. [6].

$$C = 0.0965\left[1 - 0.42\cos\left(\frac{360N}{370}\right)\right] - 0.0075[1 - \cos(1.95N)] \tag{4}$$

- Ambient temperature

Function Ta ha calculates the variation in ambient air temperature under prevailing conditions every 24s can be expressed [7].

$$Ta = Tav + (Tmax - Tav) * Sin(Ph) \tag{5}$$

- The energy balance for the glass cover

The equation for the glass energy balance is[8]:

$$\left(\alpha_g IG_{t,\beta}\right)A_{g+}q_{e,wg\,+}q_{c,wg} + q_{r,wg} = M_g C_{p,g}\frac{dT_g}{dt} + q_{c,ga} + q_{r,ga} \tag{6}$$

- The energy balance for the Basin water

The equation for the basin water energy balance is[9] [10] [11]:

$$\left(\tau_g\tau_{\mathrm{dr}}\ \alpha_g IG_{t,H}\right)A_w + q_{b-w} = M_w C_{p,w}\frac{dT_w}{dt} + q_{e,wg} + q_{c,wg} + q_{r,wg} \tag{7}$$

- The energy balance for the Basin

The equation for the basin liner energy balance is [12]:

$$\left(\tau_g\tau_\omega\tau_{\mathrm{dr}}\ \alpha_b IG_{t,H}\right)A_b \ = M_b C_{p,b}\frac{dT_b}{dt} + q_{c,b-w} + q_{loss} \tag{8}$$

- Hourly productivity

Productivity per hour, the water vapor mass flow rate per unit time l/m^2.hr is determined by:

$$m_w = \frac{qe,wg}{hfg} = \frac{he,wg\ (Tw - Tg)}{hfg} \tag{9}$$

- Energy efficiency

η_{th} The instantaneous efficiency of a solar still is calculated by:

$$\eta_{\mathrm{th}} = ((h_{e,wg} \times (T_w - T_g))/(IG_{t,H})) \tag{10}$$

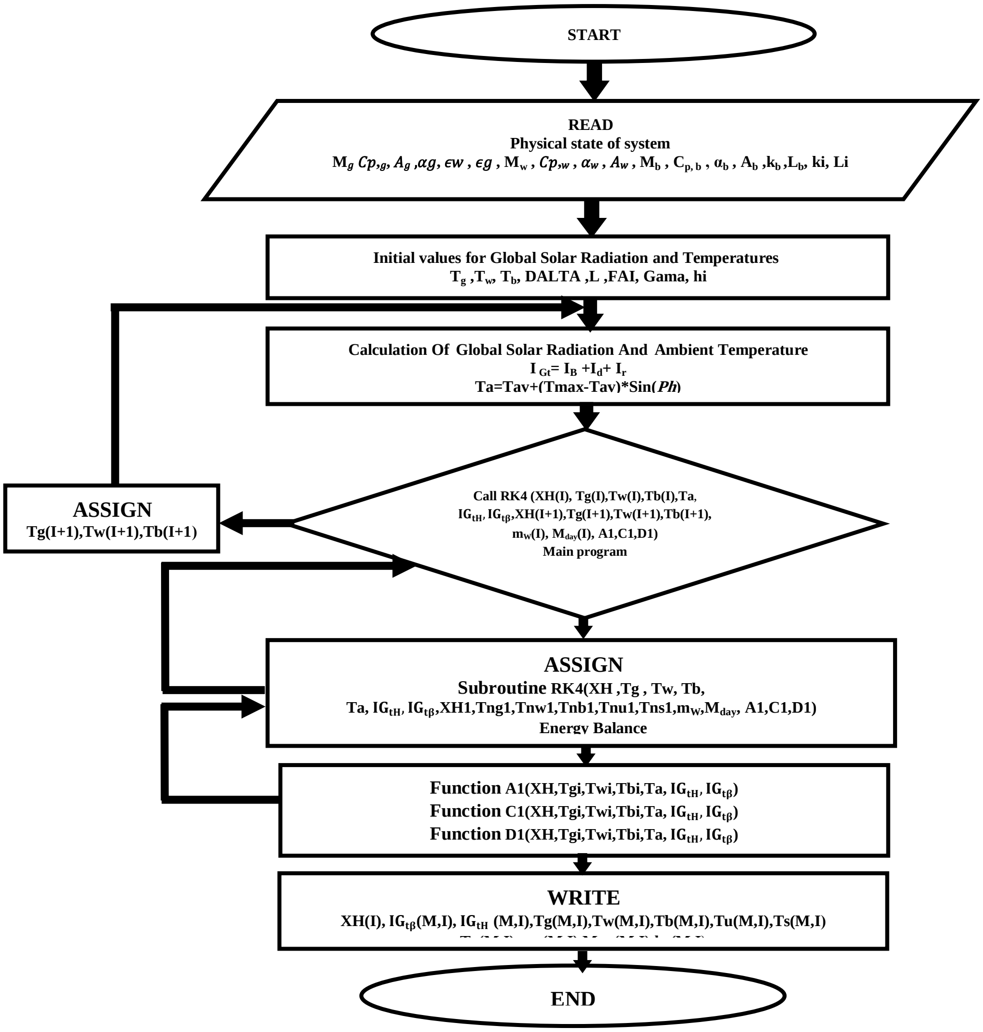

Figure 1. diagram of simulation Model

3.RESULTS AND DISCUSSION

This paper presents the simulation results obtained from the above mentioned formulae for conventional Solar Still model. Firstly, the calculation has been carried out of the monthly average of the hourly global radiation incident on tilted and horizontal surfaces and the monthly average of the hourly ambient temperature in the city of Tripoli as hourly values. Therefore, there has been a calculated amount of the monthly average of the hourly global radiation incident on tilted and horizontal surfaces through the entire year for four independent months, which represent each of them in the four seasons of January, April, July, and October of the year at the city of Tripoli, by employing Fortran95 (A compiled, language for scientific and numerical computing released in 1997) for carrying out the analysis. Secondly, calculation of glass, water, and basin temperature for Solar Still under conditions the four seasons January, April, July, and October, with theoretical water productivity in liter per meter square hour, Also, cumulative production per day and instantaneous efficiency of simple solar distiller. Considering the depth of water inside the distillation basin is 1 cm. The simulation was conducted at different months January, April, July, and October of the year .Where, have selected day-time hours started from the eight in the morning to the eight in the evening, from 8 Am to 20 Pm.

Global solar radiation incident on tilted and horizontal surfaces consists of ground reflected, diffuse, and direct radiation .certainly; here we know that global solar radiation received by an inclined and horizontal surface is summation for these rays. Figure (2) for month January (a), April (b), July (c) and October (d) respectively, present the monthly average of the hourly global solar radiation incident on tilted 35^o and horizontal surfaces in the city of Tripoli for month January, April, July, and October that represent the four reasons, against the whole year. Where Global solar radiation was calculated, maximum values for month January for a cloudless sky were over 1058 W/m^2 and 639 $W/\ m^2$ for tilted surface 35^o and horizontal surface, respectively, month April were over 1214 W/m^2 and 1035 W/m^2 for tilted surface 35^o and horizontal surface, respectively, month July were over 1033W/m^2 and 982W/m^2 for tilted surface 35^o and horizontal surface, respectively, and month October were over 1195 W/m^2 and 847 W/m^2 for tilted surface 35^o and horizontal surface, respectively. These values completely accept the reference [13] for horizontal surface.

Figure 3. Shows the variation between glass, water and basin temperatures and hourly variations for month January (a), April (b), July (c) and October (d), where glass, water and basin temperatures linearly increases during first hours of the daytime, especially, when the solar radiation is increased. The glass, water, and basin temperatures turn at certain value of hours of the daytime, this means that temperatures depend on the solar radiation and ambient temperature. Note that the Global solar radiation incident on tilted surface 35^o was used to calculate the energy equation for the glass tilted an angle of 35^o, while the Global solar radiation incident on horizontal surface was used in both energy equations for the water and the basin.

Where can be watched the maximum basin water and basin temperatures in the distillation basin were computed and found to be 71.032 ˚C and 74.749 ˚C respectively for conventional solar still with increases of ambient temperature for the month of July. The solar radiation during this period (the first hours and the last of the daytime) consist of diffuse solar radiation and reflected solar radiation only relative to tilted surfaces according to inclined angles and vertical surfaces. This represents the importance of having a good model for these components.

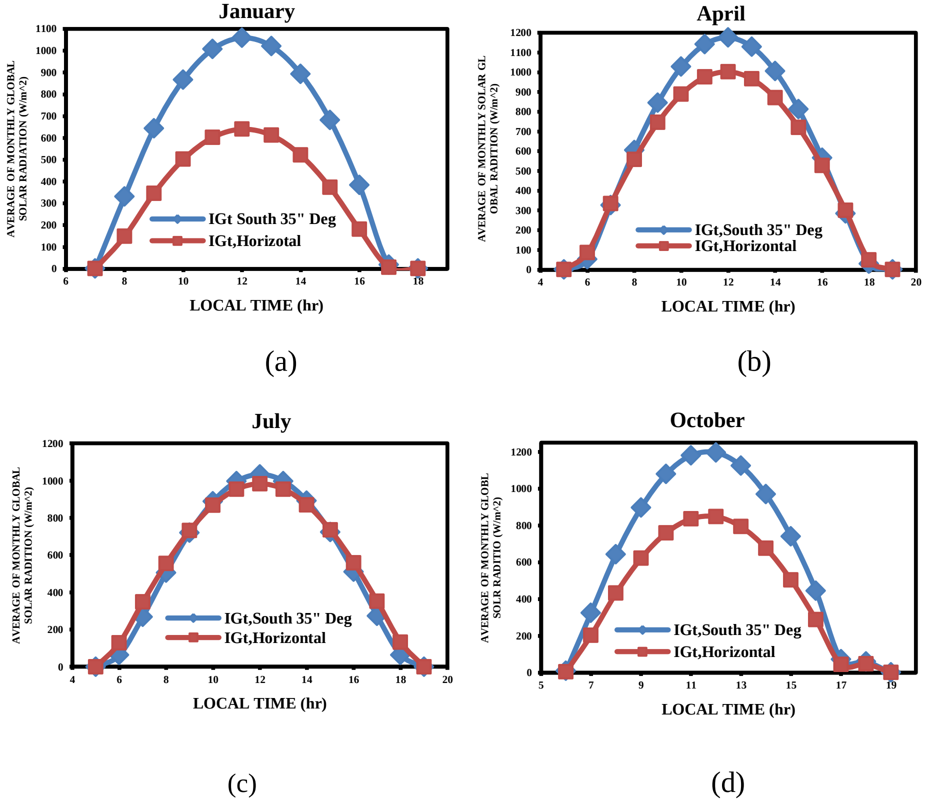

Figure 2. calculation of the monthly average of the hourly global solar radiation incident on tilted and horizontal surfaces for month January (a), April (b), July (c) and October (d).

On the other hand, the results mentioned predict an increase in productivity due to the difference in temperatures between the water in the distillation basin and the glass cover (T_w-T_g).

Figure 4 illustrates the change in hourly productivity of a conventional solar still. We note from the figure that the productivity of a conventional still is 0.537 l/m2hr, 1.292 l/m2hr, 1.303 l/m2hr and 0.935 l/m2hr as maximal value during midday for different months January, April, July and October of the year respectively, as we observe an increase in the evaporation and distillation processes, and thus, an increase in the productivity of the solar still, with the conventional distillation device stopping work at 19:00 PM.

Variation of cumulative productivity from conventional Solar Still for January, April, July, and October, basin water depth 1cm is represented in Figure 5. The cumulative productivity was 3.042 liters/m²/day, 8.621 liters/m²/day,8.945 liters/m²/day, and 5.664 liters/m²/day from 08:00 am to at 09:00 PM for January, April, July, and October respectively. The effect of solar hours of daylight on the

thermal efficiency of the solar still cycle on various the four seasons January, April, July, and October
are shown in Figure 6. This indicates that the effect of ambient temperatures and

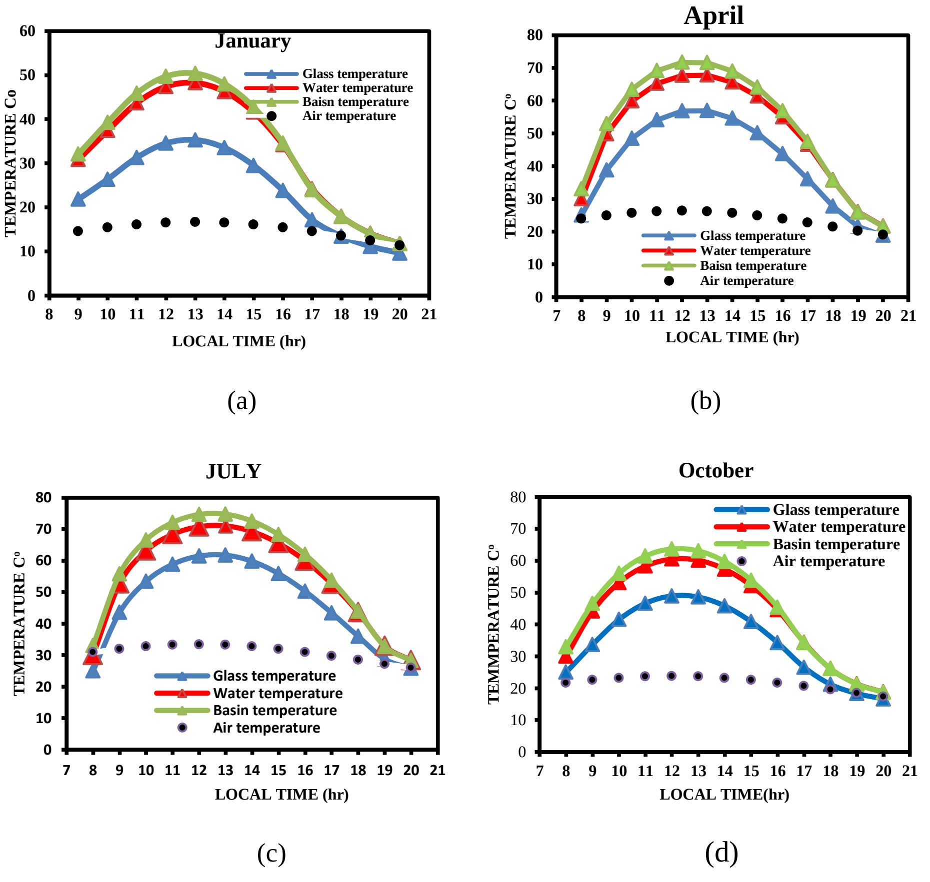

Figure 3. predicted temperatures from a mathematical model for conventional solar still for October, basin water depth 1cm for month January (a), April (b), July (c) and October (d).

hourly global solar radiation are relatively little. Increasing radiation levels with good design affects the productivity and efficiency of the Solar Still. Also it can be said, the decrease in the amount of solar radiation after 3:00 pm, while the temperature of the water layer inside the distillation basin liner remains high, makes the efficiency at this time almost constant and the curve does not slope downward at the end of the day. The highest hourly thermal efficiencies were achieved for the four months of January, April, July, and October: 0.438, 0.497, 0.695, and 0.476, respectively.

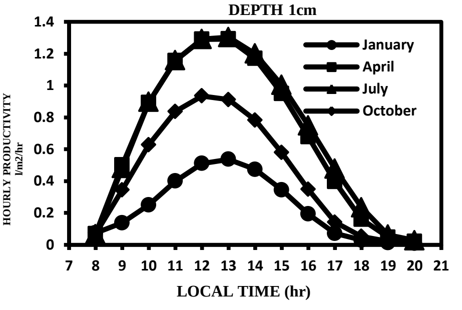

Figure 4. Hourly variation productivity for the conventional solar still for January, April, July And October, basin water depth 1cm

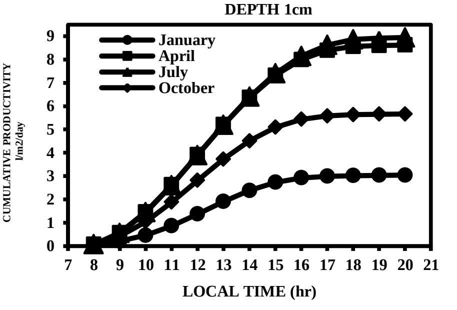

Figure 5. Variation of cumulative productivity from conventional solar still for January, April ,July, and October, basin water depth 1cm

4.Conclusion

This paper presents a qualitative study in the city of Tripoli and to the extent in which available resources can be utilized. A simulation of a conventional Solar Still was conducted, and consequently, evaluative and estimated results were obtained to establish a preliminary basis for practical experiment and model, and subsequent large-scale implementation by finding a suitable location, and taking into account the economic and design perspectives. As several Solar Stills can be built with the addition of a heat source to fill the night-time and effectiveness of the Stills. In any case, the results in this paper were indicative, predicting the possibility of desalinating drinking water and treating it microbially (sterilizing water) after collection. According to this study, the total productivity from 8:00 am. to 18:00 pm for the months of January, April, July, and October was 3.042 liters/m²/day,8.621 liters/m²/day,8.945 liters/m²/day, and 5.664 liters/m²/day respectively.

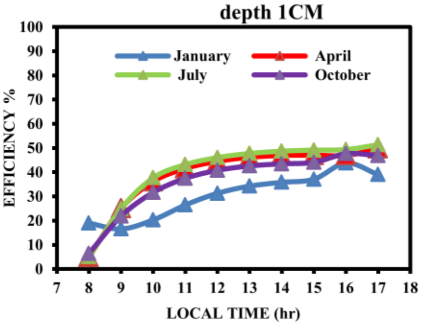

Figure 6. Variations of instantaneous efficiency from conventional solar still July, and October, basin ,for January, April water depth 1cm

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