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Techno-Economical Evaluation of a Solar Desalination System for Irrigation Purposes (Case Study on Greenhouse Bell Pepper)

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ABSTRACT

A method was proposed to predict the performance of a solar powered desalination unit used to provide water for a drip irrigation system to grow bell pepper under greenhouse conditions, and evaluate the economical prospective of such system. The results showed that the method could be used successfully to predict the performance of the desalination unit. The results indicated a strong correlation between the predicted and the measured values with a R^2 value of 0.96. The water use efficiency (*WUE*) value was 8.2 kg/m^3 and the final product unit added cost was 17.1 LE/kg.

Keywords: Greenhouse Evapotranspiration, Solar Radiation, Desalination, Cost.

INTRODUCTION

The shortage of fresh water supply is one of the major problems facing the agricultural production process nowadays. In the arid zones, the fresh water supply is much less than the water requirements of the plants. As the water, use increases and the rainfall patterns change, this is putting more stress on fresh water resources such as rivers lakes and ground water reservoirs (Ragab and Prudhomme, 2002). The depletion and the contamination of many of the fresh water resources worldwide caused this resource to be unable to meet the growing demand for fresh water (*Shiklomanov*, *1998*). Because of the fact that 70 % of the fresh water consumption worldwide is for agricultural purposes and food production the lacking of access to safe fresh water and the increasing demand for fresh water is endangering food production (*Koehler*, *2008*). Global warming is going to be more stress on the fresh water resources. In 2050, it is expected that in the Middle East countries and north Africa the rainfall rate will be reduces by about 20 -25 % with an increase in temperature of 2: 2.75 ^{o} C (Ragab and Prudhomme, 2002).

In order to keep producing food, solution to find new fresh water resources or treated water with low quality to be able to use in agriculture is necessary. Desalination of saline waters can offer access to large amount of water to be used in food production. Sources of saline water can be seawater, ground, or surface water. The major problem with water desalination is that it requires huge amounts of energy, which leads to increased cost, and large amounts of green gas emissions such as earlier desalination units operated in the gulf countries. Even in new improved reversed osmoses units the energy requirements is 1.8 kWh/m^3 using new, high-permeability sea water reversed osmoses SWRO membrane (*Elimelech and Phillip, 2011*). The cost of the most common commercial desalination techniques was studied and compared by several works.

The techniques included multistage flash distillation (MSF), multi effect distillation (MED), vapor compression (VC), reverse osmosis (RO) *(Wade, 1993*), and electrodialysis (ED) (*Reddy and Ghaffour, 2007* and *Greenlee*, *et al., 2009*). Although, until now desalination cost is higher than conventional fresh water treatments but in a lot of cases the developing of new fresh water resources is not possible (*Ghaffour et al., 2013*). There is a need for more desalination systems powered by renewable energy. Such systems would be more economically and ecologically appropriate than conventional systems.(Tzen and Morris, 2003). The production of fresh water by renewable energies such as photovoltaic or wind or direct and indirect solar desalination can provide fresh water to rural and low population density areas especially when conventional energy sources are not available (*Eltawil et al., 2009*). In the rural areas and deserts in Egypt, plenty of brackish and saline water is available while there are a shortage in fresh water (*Ahmad and Schmid, 2002*).

Different factors affect the output rate of a desalination unit such as the salinity of the input water, the design and technique of desalination unit and the water vapor pressure. Additional factors affect the desalination units powered by solar energy such as the solar radiation, the number of sunshine hours, and the ambient temperature. One of the most important parameters to evaluate the system performance is the specific thermal energy consumption, which is the ratio between energy supplied and the volume of distilled water *(Banat and Jwaied, 2008*).

Munns and Termaat (1986) concluded that salinity affected the growth of leaves more than the growth of the roots and that the determining factor of the plant tolerance to salinity is the maximum salt tolerated by the fully expanded leaf. *Parida and Das (2005)* reported that salinity affects plant production, and that salinity stress caused a reduction in carbohydrate production due to the reduction in photosynthesis rate in stressed plants. *Essa (2002)* found that salinity increases the sodium and colerain concentration and decreases the potassium concentration in stressed plants. Mixing saline water with desalinated water will lower the salinity level and improves the productivity and the production quality of the irrigated plants. *Ali et al. (2011)* listed the possible solar power desalination units, the list included direct solar desalination such as solar stills and humidification and dehumidification, and indirect solar systems such as solar thermal collectors with its' different applications and PV units. Standalone desalination units powered by a renewable energy can provide a solution to the problem of water secrecy in areas where saline water is available but there are no grid and the cost of energy is high. For farm application and because of the nature of agricultural production large thermal systems are not suitable because of several factors that include the wide land area requirements and need for long distance energy transporting. Small-scale solar systems provide a possible solution for the desalination of water for high value crops such as vegetables and ornamental plants where the value of the increase in the production can cover the added cost of the system (Ayoub and Alward, 1996). *Burn et al. (*2015*)* concluded that the desalination of water is not cost effective in open agriculture but would be cost effective in controlled greenhouse agriculture.

Predicting the output of a thermal solar collector usually does not involve a complicated equation for the collectors itself. The nature of the thermal processes in the collectors can be described with simple equations if the collector specification is known such as the type of the collector and its tracking mechanisms. Several researches described the performance of solar collectors and concentrators such as *Collares and Rabl, (1979)*, *Rabl (*1981*),* and Hove (2000). The problem of predicting performance of the collector is the availability of records of the metrological data. *Thornton, and Running (1999)* reported that the number of weather stations that record the daily solar radiation is fairly small compared to the weather stations that record maximum and minimum temperatures.

Even station with solar data gives the total daily solar radiation and it is very rear to find the hourly solar radiation needed for prediction of the output of several solar power collectors. To provide the needed solar data for the prediction of solar collector performance several approaches have been used such as work of Elizondo et al. (1994) and Mellit, (2008) which used metrological data and daily solar radiation to provide generated hourly solar radiation using artificial intelligence techniques. For an unclear or a cloudy day, the problem is even bigger the values of the solar radiation of such days can vary with the type of the cloud cover and the duration. This type of data is rarely available for most sites wide world. Hargreaves and Samani (1982) and Richardson (1985) used the difference between the daily maximum and minimum temperature as an indicator of the cloudiness of the day.

They based their model on the assumption that the cloud cover will decrease the amount of solar radiation reaching the ground thus decreasing the maximum daily temperature and will stop the reflecting long wave radiation thus increasing the minimum daily temperature.

Several modifications and new approaches for the estimation of solar radiation were suggested by Samani et al. (1987). Allen (1997) used a self-calibrating model to predict the solar radiation of an unclear day he validated the model using data from weather stations in different location to represent most climatic conditions. He found that the calibrating of the model improved the accuracy of the predicted data. Alzoheiry (2018) proposed a modification to improve the predictions of Hargreaves and Samani and reported that the modifications reduced the mean absolute error of prediction by more than 50%

Most of the models predicting the performance of solar collectors are designed for large-scale solar collectors therefore most of the models are either very complicated and hard to use or huge amounts of data are required for the model. Thus, the aim of this work is to describe a technical approach to predict the performance of a standalone solar power desalination system to provide dieselized water for an irrigation system to grow high value crops, and explore the potentials of such system economically.

MATERIALS AND METHODS

Materials

A standalone solar powered desalination system was used in this study. The system was a thermal type solar system equipped with a vacuum unite to facilitate the water evaporation and increase the system output. The system also used the resulting vapor to preheat the water entering the boiler to increase the energy efficiency of the system.

1. The solar desalination unit

The system used to validation the model was a parabolic dish solar collection (PDSC), the system consisted of the collector unit, the evaporation unit, and the condensing unit.

a) The collector unit

A parabolic dish solar collector was used for solar energy gathering (Fig. 1). The dish was a 1.7 m aluminum dish with a total surface area of 2.5 m^2, the inside surface was covered with highly reflective mirrors.

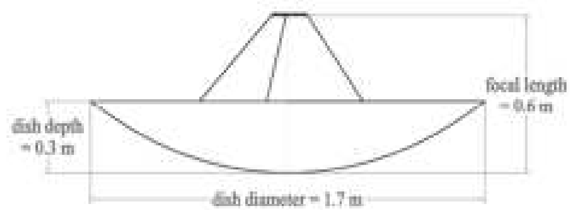

Fig. 1. Sketch of the solar dish

A copper coil tube was used as the water heater and was inserted in the focal point of the dish (Fig. 2).

Fig. 2. The water heater

The solar collector was equipped with a solar tracing system with 2 motors 8 watt each tracing the sun in two-axis to enable the collection of the maximum possible amount of the solar energy.

b) The evaporation unit

The unit consists of an evaporation chamber and a vacuum pump. The evaporation chamber is a 35 cm cylindrical chamber with a total height of 63 cm (Fig. 3).

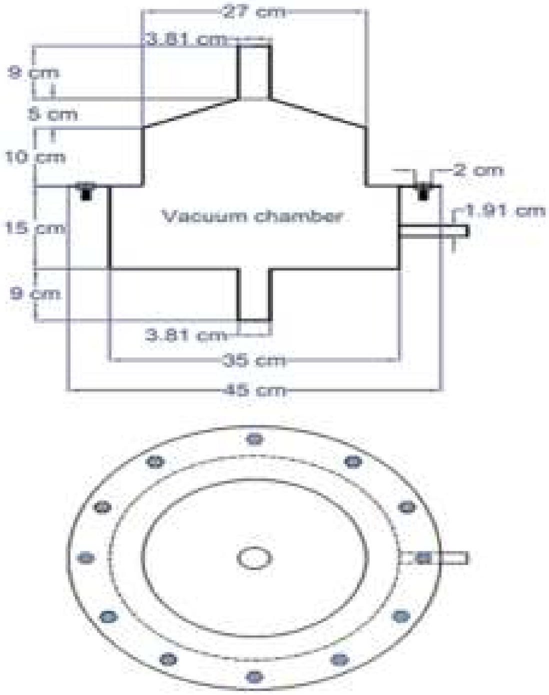

Fig. 3. The vacuum chamber

c) The condensation unit

The condensation unit is shown in Fig. (4), it consists of a cylindrical water tank equipped with two copper coils for the condensation of the water vapor and preheating of the water entering the boiler.

The system motors and the vacuum pump were powered by a solar PV array (Figs. 5 and 6).

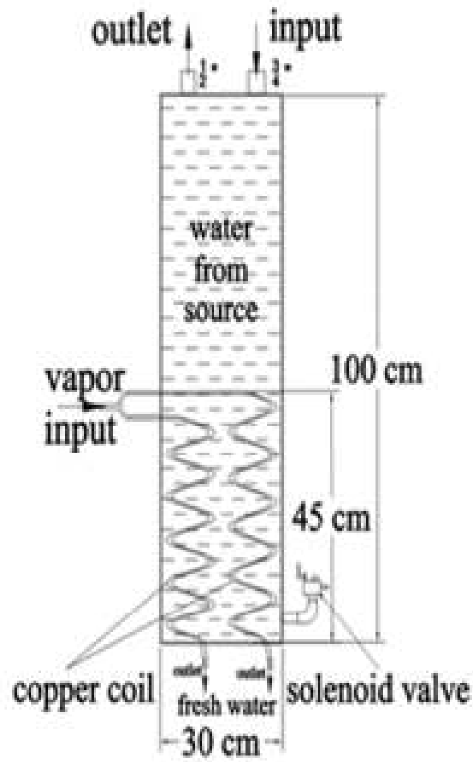

Fig. 4. The condensation unit

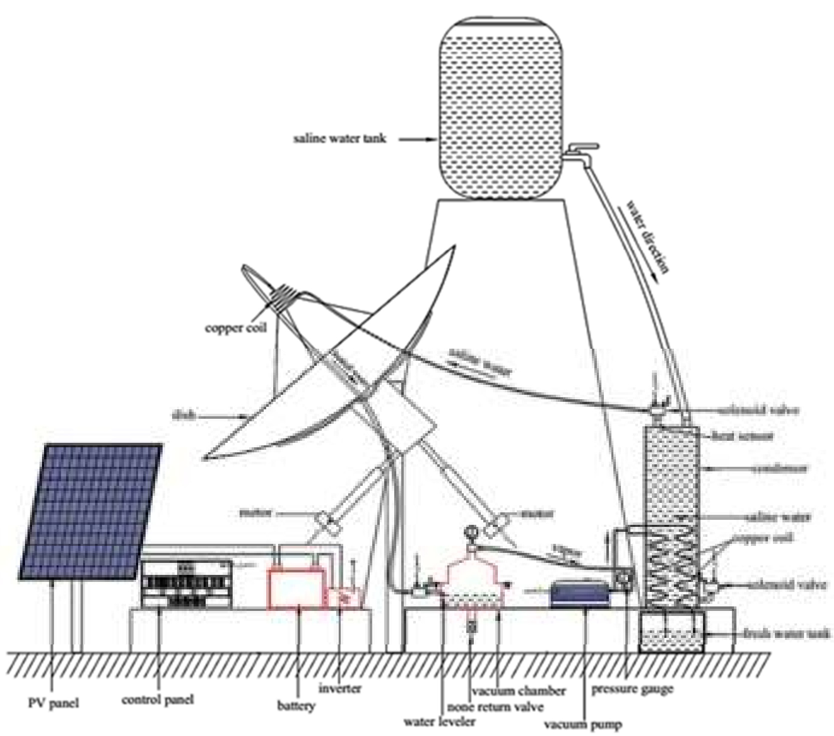

Fig. 5. Schematic diagram of the desalination system

Fig. 6. Photo of the desalination system

2. System operation

The saline water (aquifer water) goes through the condensation tank to the boiler in the focal point of the solar collector. The valves of the vacuum chamber open when the water temperature reaches 60 degrees allowing the water into the chamber, and the vacuum pump is operated when the water enters the chamber. The resulting vapor is discharged to the two copper coils inserted inside the condensation tank. Heat is exchanged inside the tank to preheat the saline water going to the boiler and condense the vapor coming from the vacuum chamber.

Methods

Metrological data and location

Metrological data used in the prediction of the performance of the solar powered desalination unit is for Alexandria, Egypt (31°12' 29'' N.29° 58' 32'' E.). Data included maximum and minimum temperatures, hourly solar radiation, daily hours of sun light, and the sunrise and sunset time. The water available is ground water (EC=3.17 dS m^{-1})

Clear day solar radiation

Predicting the clear day solar radiation based on the location and the elevation and the time of the year was conducted according to *Allen (1995 and 1996)* as follows:

$$R_{so} = K_T R_a \text{ ....(1)}$$

Where:

R_{so} = the clear sky solar radiation on a horizontal plan, MJ m^{-2} day $^{-1}$;
R_a = the extraterrestrial radiation, MJ m^{-2} day $^{-1}$;
K_T = the transmission index

$$K_T = K_B + K_D \text{ ....(2)}$$

K_B = transmission coefficient of the direct solar beam

$$K_B = 0.98 \exp\left[\frac{-0.00146P}{K_{tb} \sin \alpha} - 0.091\left(\frac{w}{\sin \alpha}\right)^{0.25}\right] \text{ ....(3)}$$

w = the perceptible water in the atmosphere, mm;

$$w = 014 e_d P + 2.1 \text{ ....(4)}$$

P =atmospheric pressure, kPa;
K_{tb} is the clarity coefficient
σ = the mean 24-hour solar altitude

$$\sigma = 0.85 + 0.3\, \varphi \sin\left(\frac{2\pi}{365} D - 1.39\right) - 0.42\varphi^2 \text{ ....(5)}$$

D = the day of the year
φ = the latitude in radians
K_D = the transmission coefficient of the diffused short wave radiation

$$K_D = 0.35 - 0.33 K_B \; for \; K_B \geq 0.15 \text{ ....(6)}$$

$$K_D = 0.18 - 0.82 K_B \; for \; K_B < 0.15 \text{ ....(7)}$$

Unclear day solar radiation

The solar radiation of an unclear day, equation (8), was predicted using Alzoheiry model (*Alzoheiry, 2018*)

$$R = a\, I \left((T_{max} - T_{min}) \frac{e_{Tav}}{e_{Tmax}}\right)^{0.5} \text{ ....(8)}$$

Where:

R =daily actual global solar radiation (horizontal surface), MJ m^{-2}day $^{-1}$;
a = 0.16
I = Extraterrestrial solar radiation on a horizontal surface, MJ m^{-2} day $^{-1}$;
T_{max} *and* T_{min} = the maximum and minimum daily temperature respectively, ºC;
e_{Tav} = saturation vapor pressure at T_{av}
e_{Tmax} = saturation vapor pressure at T_{max}

The saturation vapor pressure (e) at temperature (T_n) can be calculated from equation (9)

$$e\,(T_n) = 0.6108 \exp\left(\frac{17.27 T_n}{(T_n + 237.3)}\right) \text{ ....(9)}$$

Where:

$e\,(T_n)$ = the saturation vapor pressure at temperature T_n, kPa.

Hourly solar radiation

Generating the hourly solar radiation values is a much bigger problem. The methods that use the artificial intelligence and the time series methods require large amounts of historical data that is not available in a lot of sites and was not available for the study site. A proposed method for the estimation of the approximate values of the hourly solar radiation depend on evaluating the values of the extraterrestrial hourly solar radiation according to the method described by *Allen (1996)*. The hourly solar radiation can be generated as follows:

a) All the predicted values of the extraterrestrial solar radiation are written as ratio from to the largest value predicted during the day, equation (10)

$$I_i = w_i I_{max} \text{ ....(10)}$$

Where:

I_i = the extraterrestrial solar radiation at hour I, MJ m^{-2} h^{-1};
W_i= the ratio between the hourly extraterrestrial solar radiation at hour I and the maximum value of the extraterrestrial solar radiation recorded during the day, dimensionless;
I_{max}= the maximum value of the extraterrestrial solar radiation recorded during the day, MJ m^{-2} h^{-1}.

The method assumes that area under the curve of the hourly solar radiation gives the daily solar radiation thus the value of the daily solar radiation value is equal to the integration of the curve passing through the values of the hourly solar radiation.

b) The numerical integration formula of the daily value of the solar radiation is written using the notation in number (a)

$$R = \frac{h}{3}\left[S_0 + 4\sum_{i=1,odd}^{n-1} S_i + 2\sum_{j=2,even}^{n-2} S_j + S_n\right] \text{………..(11)}$$

Where:

R = the total daily global solar radiation, MJ m^{-2} day^{-1};
h = the time interval, one hour;
So = the hourly solar radiation at sunrise. MJ m^{-2} h^{-1};
Si , Sj = the hourly solar radiation at i and j, MJ m^{-2} h^{-1};
S_n = hourly solar radiation at sunset, MJ m^{-2} h^{-1}.

The value of S can be expressed as follows:

$$S_i = Cw_i I_{max} \text{ …………(12)}$$

Where:

C = a constant that represent the relation between the extraterrestrial solar radiation and the solar radiation reaching the ground surface in the desired location.

Substituting from equations (10 and 12) into equation (11) gives:

$$R = \frac{h}{3}\left[Cw_0 I_{max} + 4\sum_{i=1,odd}^{n-1} Cw_i I_{max} + 2\sum_{j=2,even}^{n-2} Cw_j I_{max} + Cw_n I_{max}\right] \text{……(13)}$$

$$R = \frac{hCI_{max}}{3}\left[w_0 + 4\sum_{i=1,odd}^{n-1} w_i + 2\sum_{j=2,even}^{n-2} w_j + w_n\right] \text{…………(14)}$$

Then using the value predicted for R from the unclear model the values of C can be determined for each day and then the values of the hourly solar radiation can be predicted using equation (12). A correlation equation between the hourly solar radiation and the output of the solar desalination unit were used to predict the expected amount of the desalinated water output (*Nassar et al. 2015*). The resulting predicted and measured values were compared and the model was evaluated based on the mean absolute error (*MAE*) value according to *Willmott and Matsuura (2005)*.

Reference evapotranspiration in the greenhouse ($ET_{o\ green}$)

The reference evapotranspiration ($ET_{o\ green}$) in the greenhouse was estimated using the method of *Fernández et al., (2010),* the method uses an empirical equations (15 and 16) based on solar radiation to predict the $ET_{o\ green}$ as follows:

$$ET_{o\,green} = R_{green}(0.288 + 0.0019 \times Y) \qquad for\ Y < 220 \text{……..(15)}$$

$$ET_{o\,green} = R_{green}(1.339 - 0.00288 \times Y) \qquad for\ Y > 220 \text{……(16)}$$

Where:

$ET_{o\,green}$= reference evapotranspiration in the greenhouse, mm day^{-1};
Y = the day of the year (starting Jan -first as day 1)
R_{green}= the solar radiation in the greenhouse, mm day^{-1};

$$R_{green} = R \times \tau$$

τ = the transmissivity of the greenhouse material
= 0.75 for stander greenhouse plastic.

Irrigation

The calculation of the crop evapotranspiration (ET_c) of the bell pepper, crop coefficient, and the length of each growing stage was according to *FAO 56* (*Allen 1998*).

Pepper plants were planted in 3 cylindrical lysimeters to determine the actual crop evapotranspiration then using the crop coefficients to calculate the actual reference evapotranspiration. A standard 9x 60 m greenhouse was used in the study, and the pepper plants were planted on raised beds 1.6 m in spacing. A 2 l/h dripper line with drip spacing of 50 cm between dippers resulting in a plant density of 3 plants /m^2. The irrigation of the raised beds were according to the irrigation cycles of the lysimeters. The total yield of the pepper was recorded at the end of the experiment.

Desalination total costs

The added expenses due to the desalination unit were calculated according to *Kabeel et al. (2010)* as follows:

The capital return factor (*CRF*)

$$CRF = \frac{i(i+1)^n}{(1+i)^{n-1}} \text{ … … … … } (17)$$

Where

i = the annual interest rate, %;
n = average expected life of the system, year;

Fixed annual cost (*FAC*)

$$FAC = P(CRF) \text{ … … … … } (18)$$

Where:

***FAC*= Fixed annual cost, LE/year;**
***P* = Present capital cost of the system, LE;**

Sinking fund factor (*SFF*)

$$SFF = \frac{i}{(1+i)^{n-1}} \text{ … … … … } (19)$$

The salvage value (*S*)

$$S = 0.2P \text{ … … … … } (20)$$

Where:

***S* = Salvage value, LE.**

Annual salvage value (*ASV*)

$$ASV = S(SFF) \text{ … … … … } (21)$$

Where:

***ASV* = Annual salvage value, LE/year.**

Annual maintenance and operational cost (*AMC*)

$$AMC = 0.15\ (FAC) \text{ … … … … } (22)$$

Where:

***AMC* = Annual maintenance and operational cost, LE/year.**

Annual cost (*AC*)

$$AC = FAC + AMC - ASV \text{ … … … … } (23)$$

Where:

***AC* = Annual cost, LE/year.**

The system average yearly operating hours were calculated bassed on the total yearly sunshine hours (*Allen 1998*)

The total amount of desalinated water for each mass unit of the final product was determined based on a mixing ratio of 1 liter of saline water to 0.5 litter of desalinated water (2:1 ratio) this value was determined based on the work of *Kurunc et al. (2011)*. The fruit yield was determined and the water use efficiency (*WUE*) was calculated by dividing the total fruit yield weight (Kg) on by the total amount of water used (m^3) during the season.

RESULTS AND DISCUSSION

1. Reference Evapotranspiration (*Eto*) and Water Use Efficiency (*WUE*)

The reference evapotranspiration values predicted inside the greenhouse *PGETo* and the actual reference evapotranspiration values *AGETo* are shown in Fig. (7).

The values of The *PGETo* were almost always higher than the values of *AGETo*. The value of the mean bias error of the prediction *MBE* was -0.78 mm day^{-1} indicating that the equation used for prediction tends to overestimate the values of the ET_O. The total predicted seasonal crop evapotranspiration was 370.8 mm and the actual total seasonal crop evapotranspiration was 324.6 mm with an overall over estimation of 15 %. The total irrigation of the season was 3831.4 m^3 ha^{-1} resulting in a *WUE* of 8.2 Kg m^{-3}. The amount of seasonal evapotranspiration (reference, crop) and total amount of irrigation were less than what was reported by *Sezen et al. (2006),* who reported a total seasonal crop evapotranspiration of 465 mm day^{-1}. They also reported a lower *WUE* of 6.5 Kg m^{-3}. The difference in the results is because they conducted their experiment in open field and the current study was conducted in a greenhouse causing less evapotranspiration and less water consumption and a higher *WUE*.

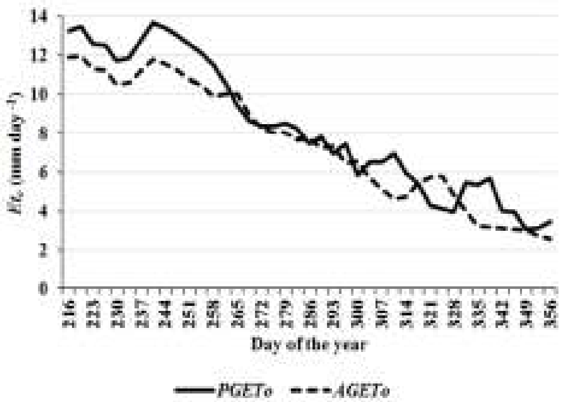

Fig. 7. Predicted and actual evapotranspiration

2. Desalination System Performance

The hourly solar radiation predicted for a typical day is shown in Fig. (8) the predicted daily solar radiation was 23.4 MJ m^{-2} day^{-1}, while the measured was 26.3 MJ m^{-2} day^{-1}. The values of the extraterrestrial solar radiation (I_i) for the day started from 0.12 MJ m^{-2} h^{-1} at 5:30 am and reached a maximum of 4.61 MJ m^{-2} h^{-1} at 12:30 pm then decreased after that to a value of 0.32 MJ m^{-2} h^{-1} before sunset. The value of the constant *C* (equation 12) of this day was determined using equation 14 as 0.202 then equation 12 was used to predict the hourly solar radiation. The maximum value of the predicted hourly solar radiation was 0.93 MJ m^{-2} h^{-1} while the maximum measured hourly solar radiation was 1.01 MJ m^{-2} h^{-1} both at 12:30 pm with a prediction error of 8%. Fig. (8) shows that the method slightly over predicts the smaller values of solar radiation at both ends of the day and underestimates the values in the middle of the day. The daily mean absolute error (*MAE*) of the prediction was 0.12 MJ m^{-2} h^{-1} this indicates that the predicted values are very close to the measured values. The discrepancy in the values of the hourly solar radiation is mainly because the method assumes a uniform cloud cover throughout the day and this is not the case in the actual cloud cover during the day.

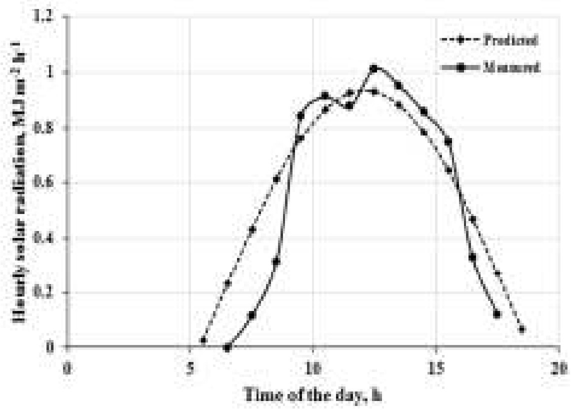

Fig. 8. The predicted and measured hourly solar radiation in any given day

The predicted value of the total productivity of the desalination system in the day 216 was 20.45 L $m^{-2}day^{-1}$ and the measured productivity value for the same day was 21.47 L $m^{-2}day^{-1}$ with a prediction error 4.7 %. The comparison between the predicted and measured productivity of the desalination unit for the complete growing season indicates a strong correlation between the values with a R^2 value of 0.96.

3. Cost analysis

The cost analysis of the system is summarized in Table (1). The salvage values of all the system components were fixed at 20 % of the original price. The system has a very low requirement of maintenance and labor, and there are no external energy needed.

Table 1. Cost analysis of the desalination system

P, LE	*CRF*	*FAC*, LE/year	*SFF*	*S*, LE	*ASV*, LE/year	*AMC*, LE/year	*AC*, LE/year	*AC*, LE/litre
5400	0.20	1074.06	0.01	1080.00	9.30	161.11	1225.87	0.42

***P*= present capital cost, *CRF*= capital return factor, *FAC*= fixed annual cost, *SFF*= sinking fund factor, *S*= salvage value, *ASV*= annual salvage value, *AMC*= annual maintenance and operational cost, *AC*= annual cost.**

The total cost of the desalinated water was 0.42 LE/L. with a mixing ratio of 2:1 (saline to desalinated) water and a *WUE* of 8.2 Kg m^{-3} the final cost added to the product price would be 17.1 LE /kg and this cost can be considered high cost. However, the desalination and the mixing will reduce the water electric conductivity (EC) from 3.17 dS m^{-1} to 2 dS m^{-1}. The reduction in the water salinity would increase the total yield from 78% of the maximum possible yield (irrigated with water less than 1.2 dS m^{-1}) to a total yield of 92% of the maximum possible yield (*Kurunc et al. 2011*) while preserving the soil and avoiding the need for leaching requirement. Fourteen percent of the maximum possible yield increase could compensate for a portion of the added cost caused by the desalination system. In addition, the system open the possibility for irrigating using water that would has been unusable if the desalination and the mixing processes were not available this may decrease the pressure on the fresh water resources and prolong the production processes in areas where the excessive consumption of aquifer water caused the increase of its' salinity.

CONCLUSION

A method for predicting the performance of a solar desalination unit was proposed. The method predict the performance of the desalination unit using basic metrological data that are commonly available and easy to find. The method use the daily temperature to predict the daily global solar radiation and then using the hourly extraterrestrial solar radiation generate predicted values for the hourly global solar radiation. The comparison between the predicted values and the measured values of the hourly solar radiation indicated very close correlation between the values with a daily *MAE* value of 0.12 MJ m^{-2} h^{-1}. The economical evaluation of the unit performance was studied on bell pepper planted in a greenhouse. The total predicted seasonal crop evapotranspiration was 370.8 mm while the measured was 324.6 mm with an overall over estimation of 15 %. The *WUE* was 8.2 Kg m^{-3}. The added cost to the final product price was 17.1 LE/kg and is considered high cost but this type of units could open the possibility for irrigating using water that would has been unusable if the desalination and the mixing processes were not available.

Moreover, the unit was manufactured and assembled as a prototype if more units to be manufactured the added cost will decrease because most of it are fixed costs and the variable cost needs of the system are very small.

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تقييم فني ـ اقتصادي لنظام تحلية مياه يعمل بالطاقة الشمسية لأغراض الري (دراسة حالة على الفلفل الأخضر الحلو)

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يعتبر العجز في الموارد المائية العذبة أحد أهم المشاكل التي تؤرق العالم بصفة عامة والوطن العربي بصفة خاصة، ولحل هذه المشكلة يمكن الاتجاه إلى تحلية المياه المالحة بالطاقة الشمسية. لتستخدم تقنية التحلية الشمسية بهدف سد الاحتياجات المتزايدة لمياه الشرب أو للأغراض الزراعية. وفي هذا البحث تم اقتراح نظام لتحلية المياه يعمل بالطاقة الشمسية وتم خلط المياه الناتجة من وحدة التحلية مع مياه مالحة بنسبة 2 جزء من الماء المالح إلي 1 جزء من المياه المحلاة، لتوفير المياه لنظام ري بالتنقيط لزراعة الفلفل الحلو في البيوت المحمية، وتقييم الأثر الاقتصادي لهذا النظام. أظهرت النتائج أنه يمكن استخدام النظام بنجاح للتنبؤ بأداء وحدة تحلية المياه، حيث أشارت النتائج المتوقعة لإنتاجية النظام والقيم المقاسة الفعلية لوحدة تحلية المياه خلال موسم نمو كامل إلى وجود علاقة قوية بين القيم (R^2 =0.96) وكذلك قدرت قيمة كفاءة استخدام المياه (*WUE*) 8.2 كجم / م^3، كما وجد أيضا ان التكاليف المضافة لوحدة المنتج النهائي تقدر بمقدار 17.1 جنيه / كيلوجرام وتعتبر هذه التكلفة مرتفعة، ولكن هذا النظام يمكن أن يفتح آفاق للري باستخدام المياه التي كانت غير صالحة للاستخدام وذلك عند عدم توفر أو نقص المياه العذبة.